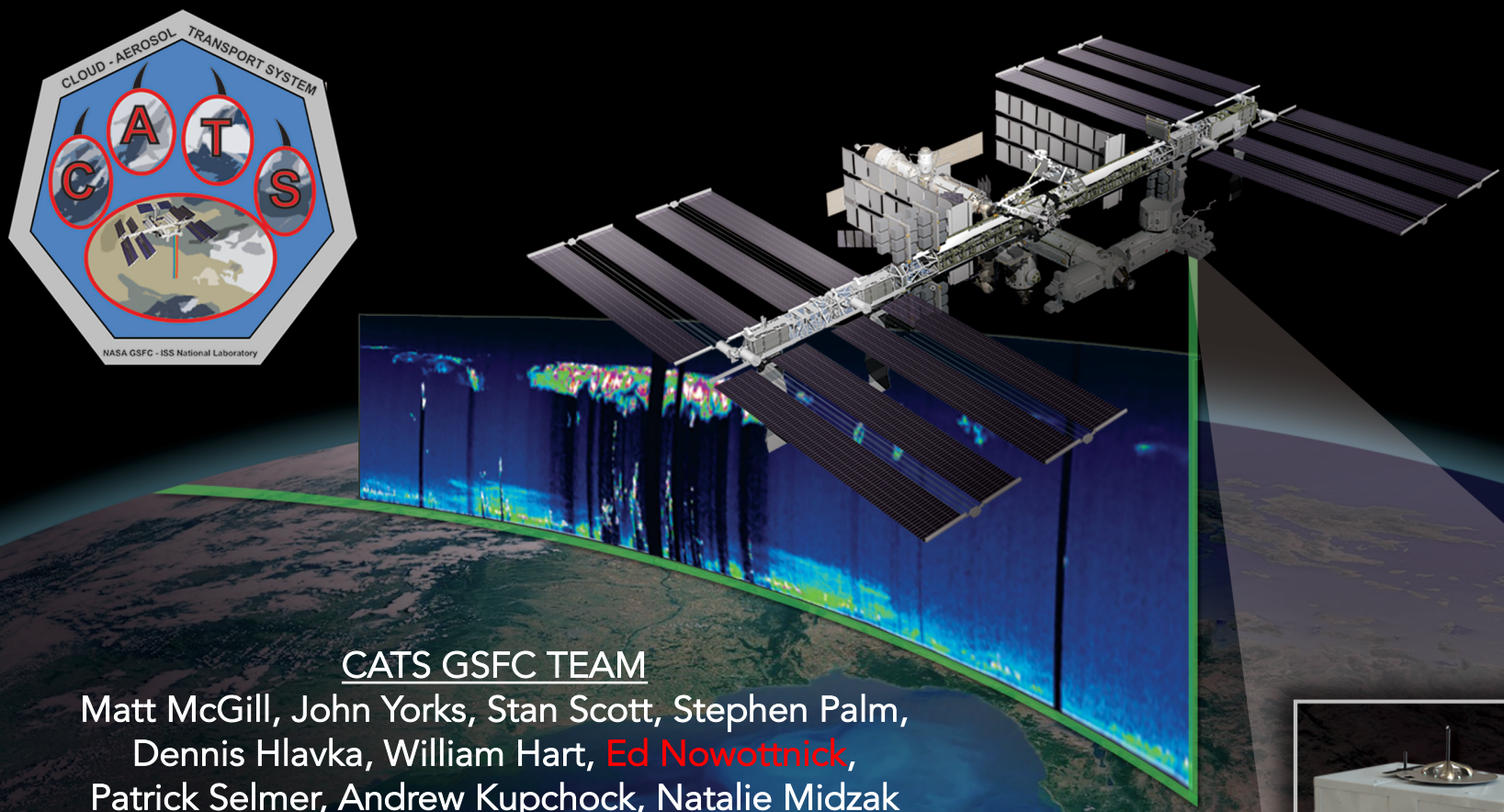
CATS Aerosol Typing and Future Directions



CATS GSFC TEAM

Matt McGill, John Yorks, Stan Scott, Stephen Palm, Dennis Hlavka, William Hart, Ed Nowottnick, Patrick Selmer, Andrew Kupchock, Natalie Midzak

CATS LaRC Team

Chip Trepte, Mark Vaughan, Sharon Rodier, Tim Murray, Mike Jensen

NASA GEOS-5 Collaborators

Peter Colarco, Arlindo da Silva, Virginie Buchard-Marchant

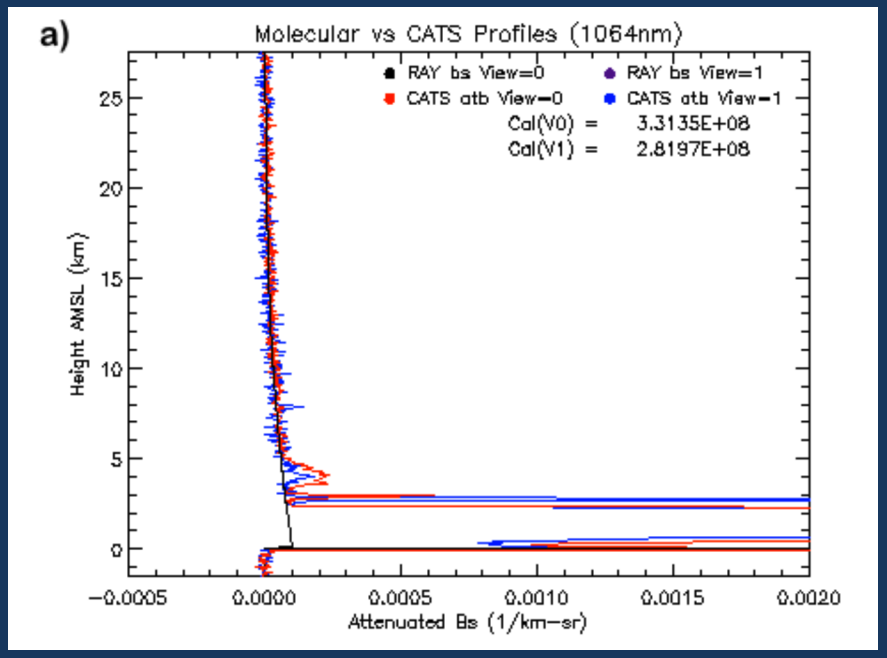
Overview

- CATS Mode 2 Aerosol Typing Algorithm
- Case Studies
- Known Issues, Challenges and Current Efforts
- CATS Mode 1 Aerosol Typing Algorithm
- Future Plans
- Getting CATS Data

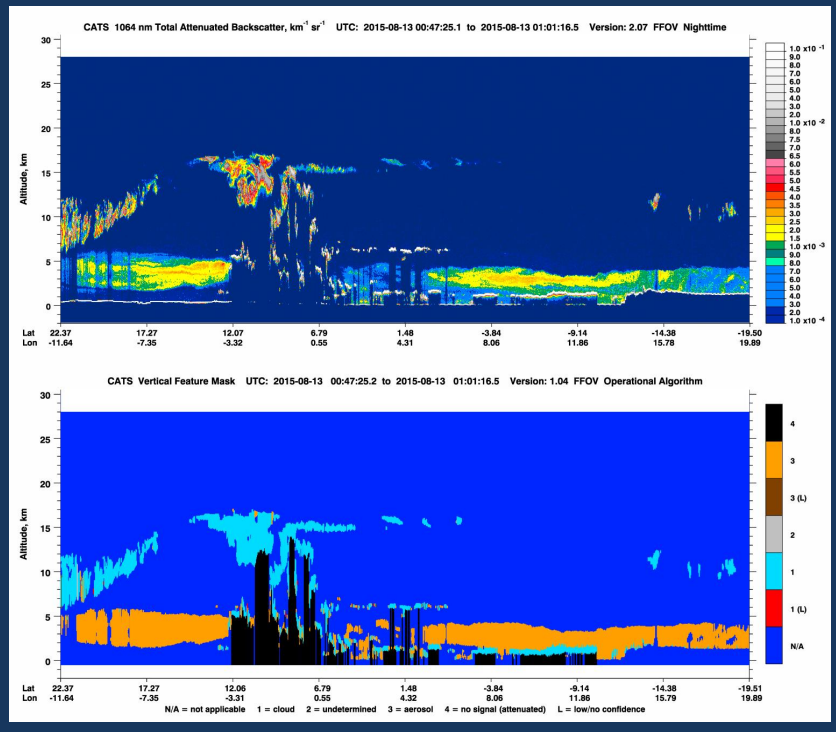
Why do we need aerosol type?

- An extinction to backscatter ratio (lidar ratio) is needed to derive extinction products from observed backscatter.
- For standard backscatter lidars like CATS, lidar ratios are assigned for aerosol types.

1. The CATS feature detection algorithm first looks for regions of enhanced attenuated scattering ratios (observed to molecular) within a 5 km averaged profile.



2. Aerosol features are discriminated from cloud features using layer integrated total attenuated backscatter, integrated depolarization ratio, temperature, thickness, and color ratio (Mode 1 only).



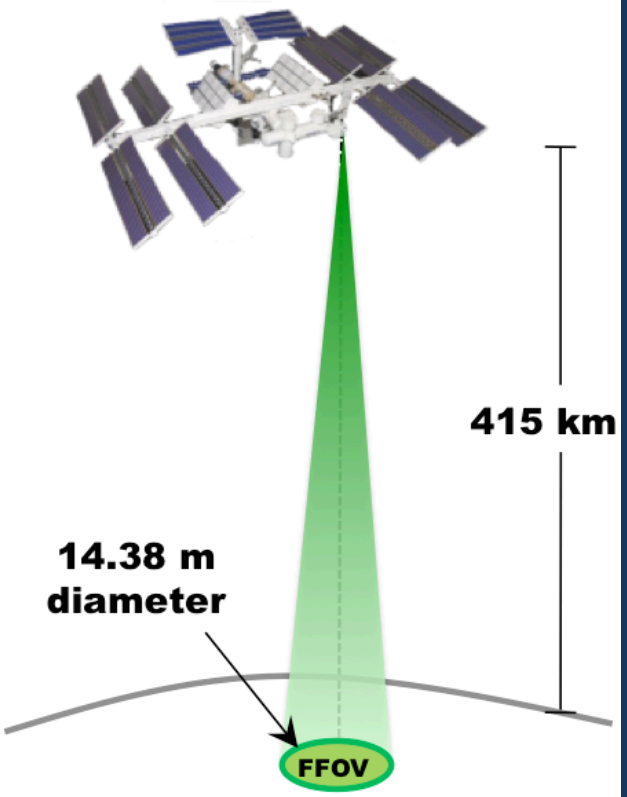
CATS Mode 2 Aerosol Typing Overview

- Backscatter and Depolarization Ratio at 1064 nm
- Backscatter at 532 nm is very noisy and is not used in the algorithm
- For our version 1 Mode 2 aerosol typing, we rely on heritage from CALIOP

Aerosol Type	1064 nm Lidar Ratio
Marine	45
Dust	55
Dust Mixture	45
Clean/Background	35
Polluted Continental	35
Smoke	40
Volcanic Sulfate	35

Mode 2: Laser 2

Backscatter: 532, 1064 nm
Depolarization: 1064 nm
L2 Products: 1064 nm



Semi-continuous operation:
25 Mar. 2015 – Present

CATS Mode 2 Aerosol Typing Overview

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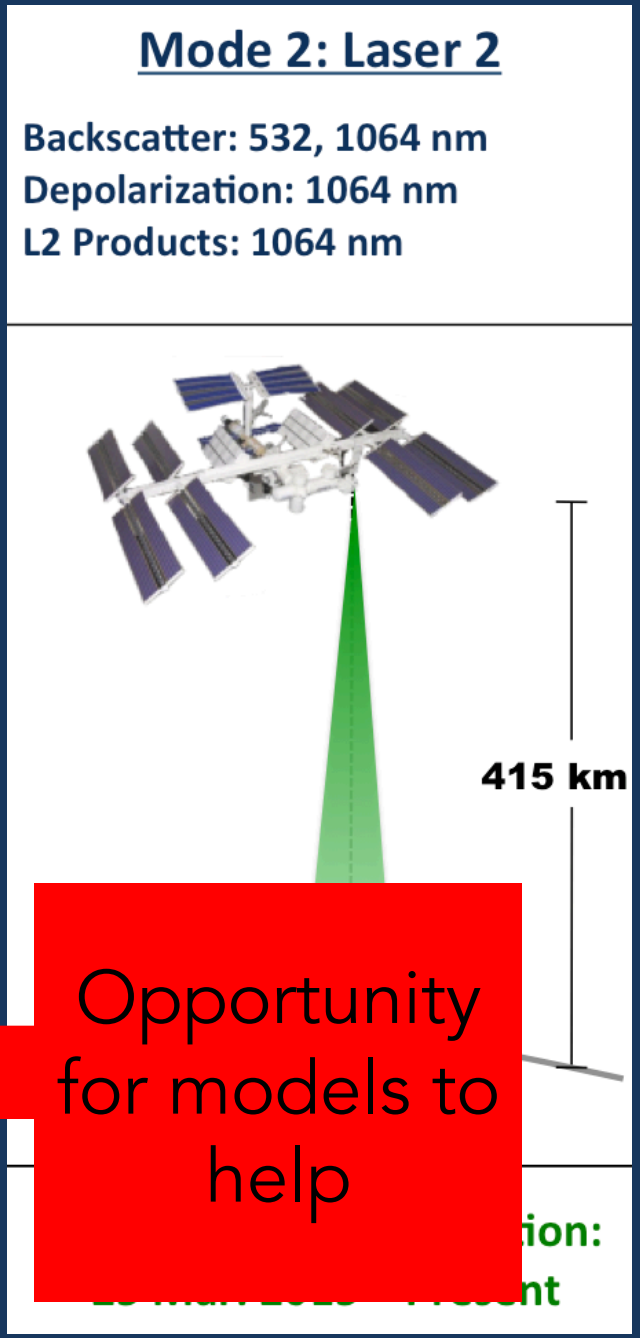
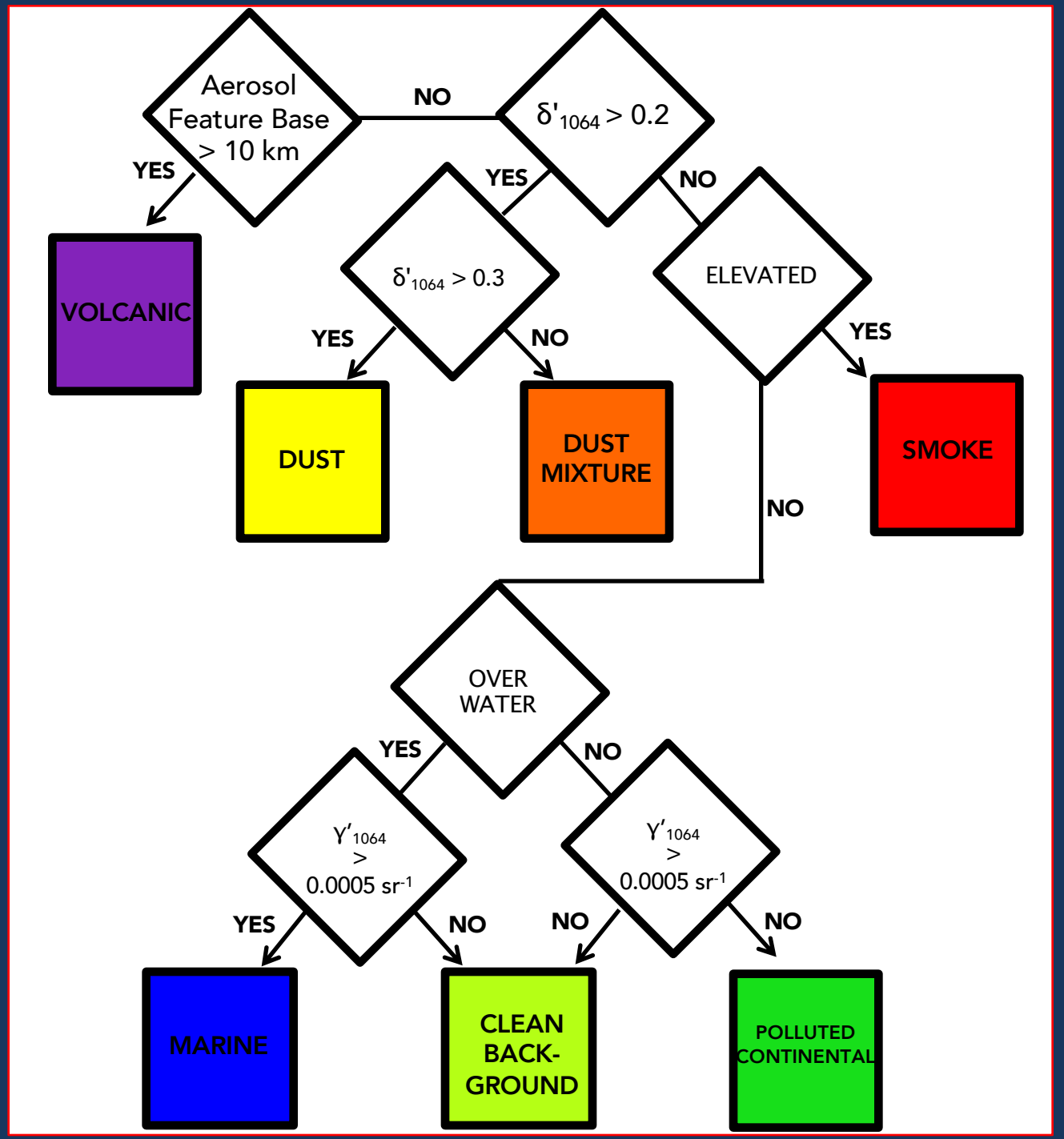


CATS Mode 2 Aerosol Typing Algorithm

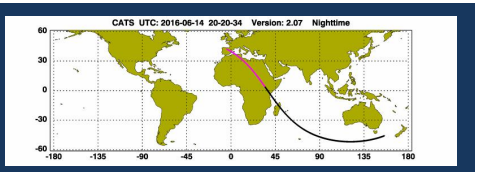
Inputs:

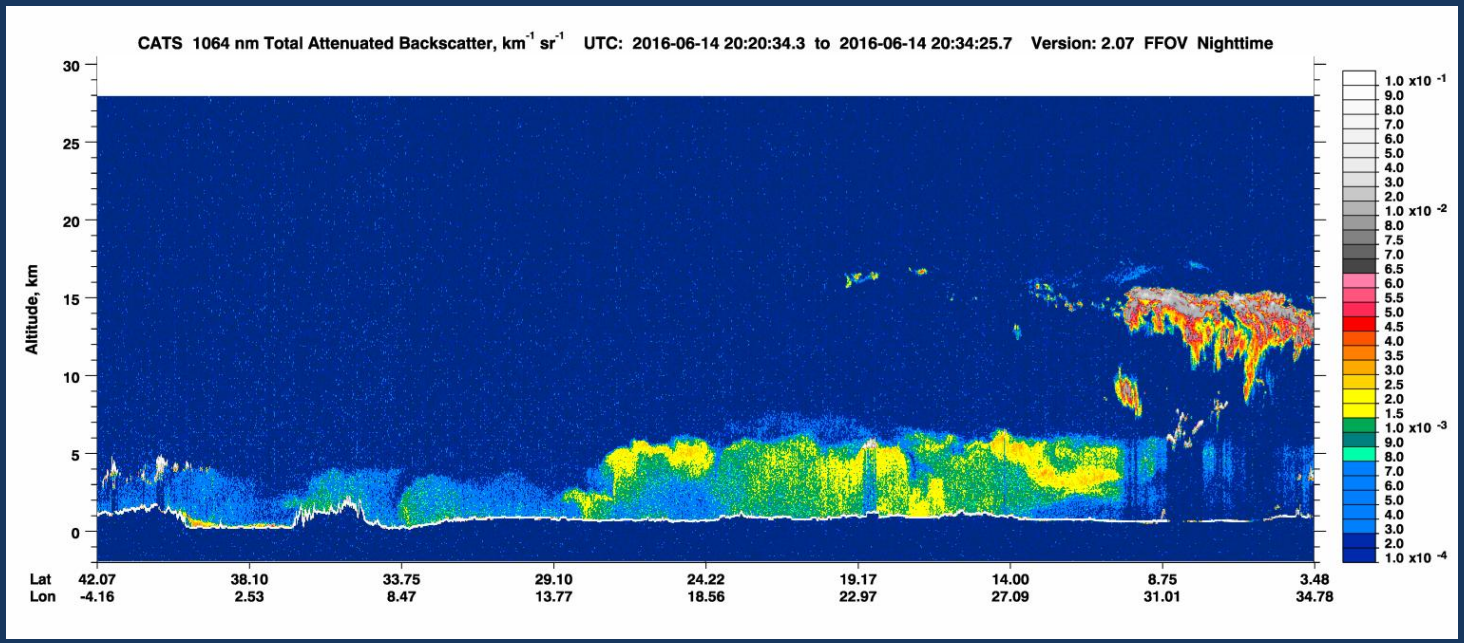
- Feature Integrated Depolarization Ratio at 1064 nm (δ'_{1064}) averaged to 5 km horizontally
- Feature Integrated Total Attenuated Backscatter at 1064 nm (γ'_{1064}) averaged to 5 km horizontally
- Surface Type (for maritime)
- Feature Altitude

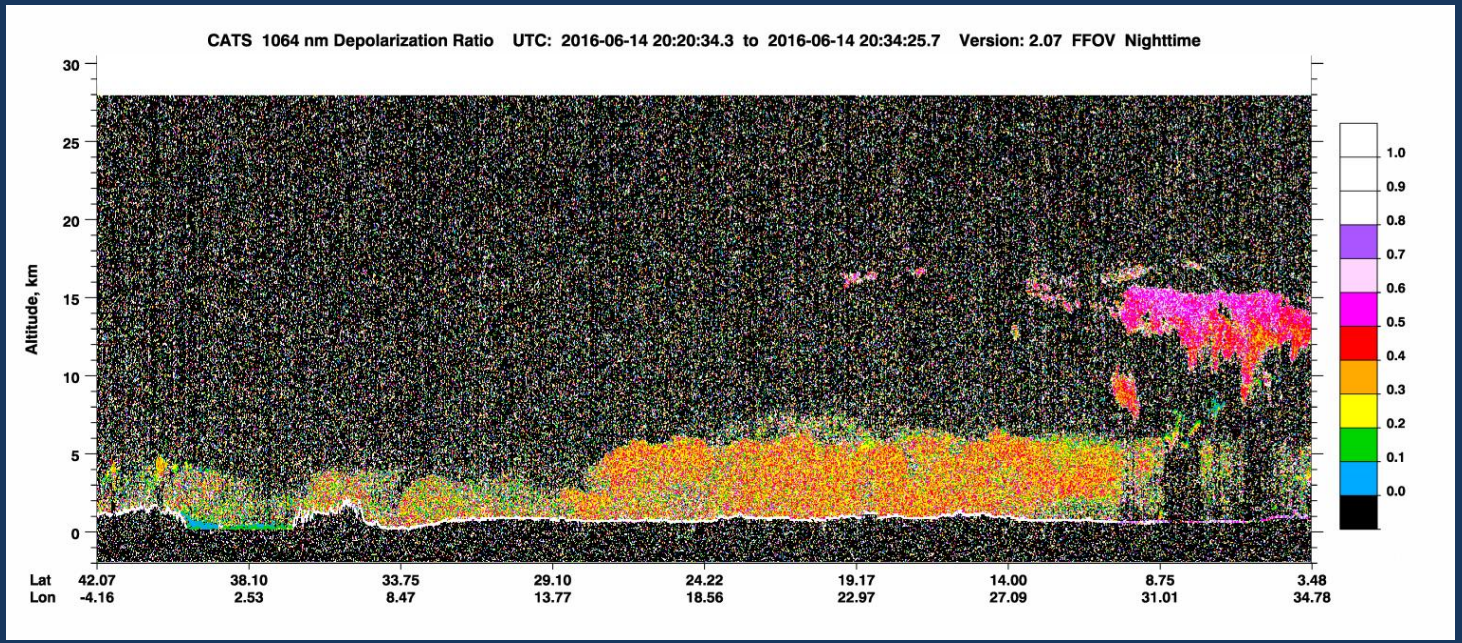
* Heritage from CALIOP aerosol typing algorithm



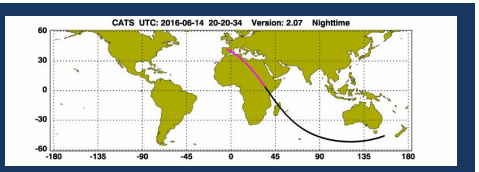
Case Study: Saharan Dust

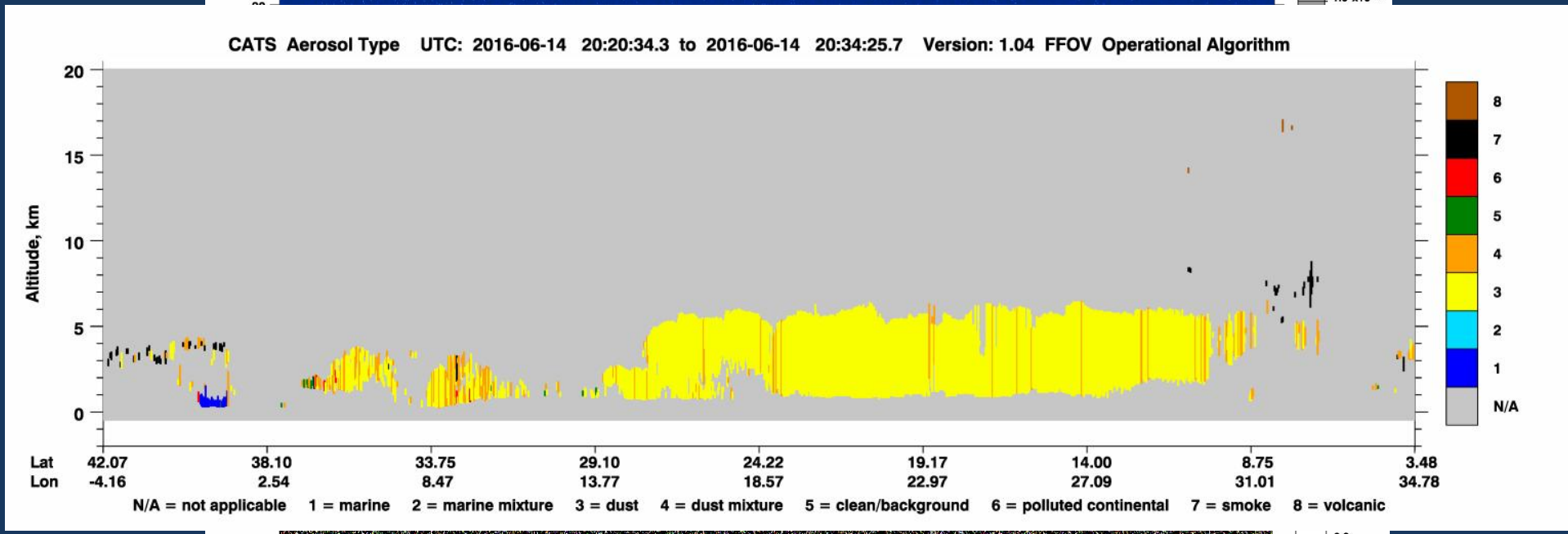


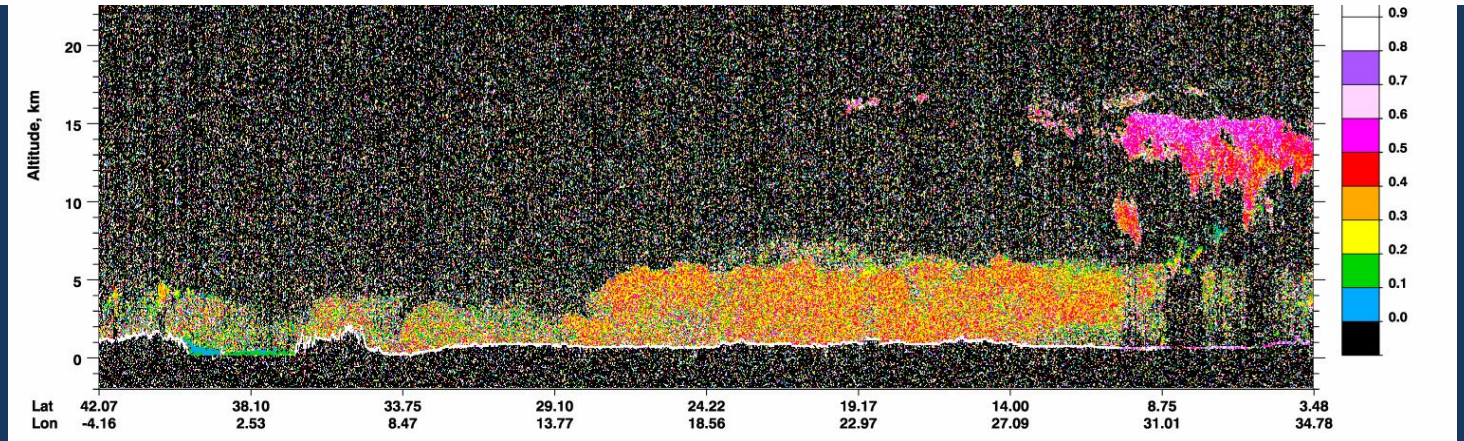




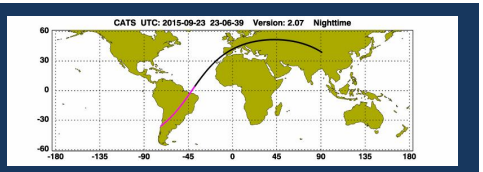
Case Study: Saharan Dust

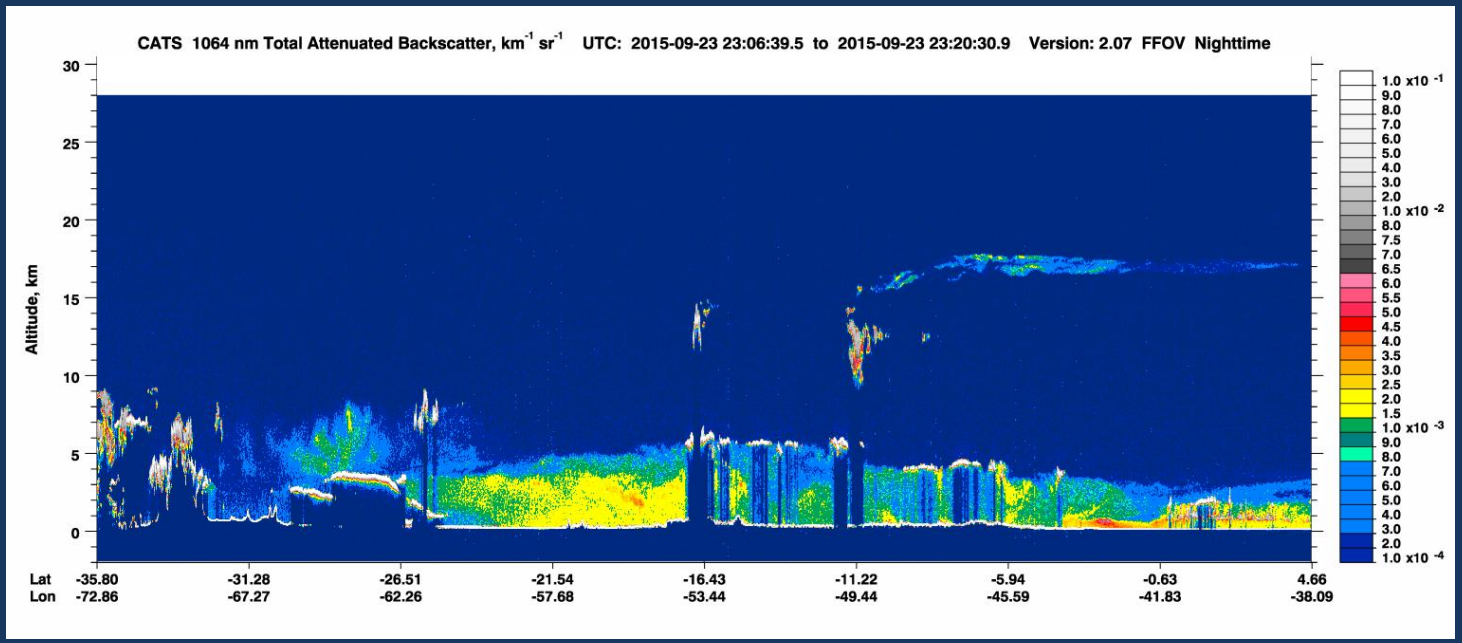


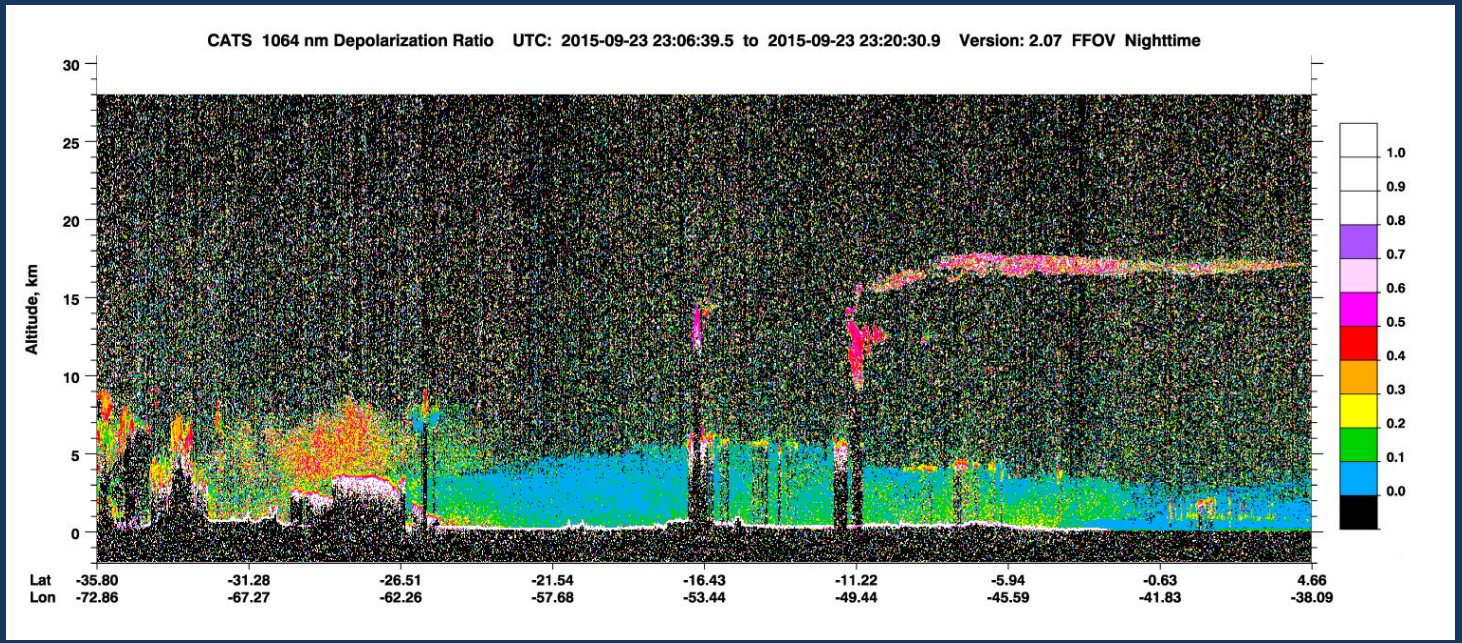




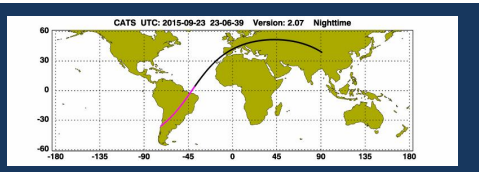
Case Study: Smoke over South America

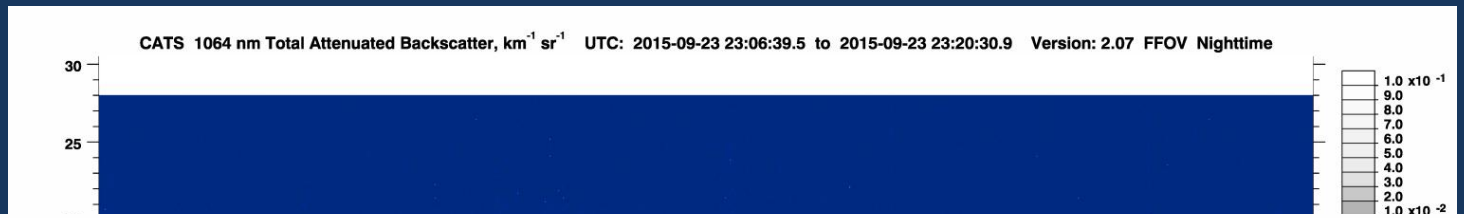


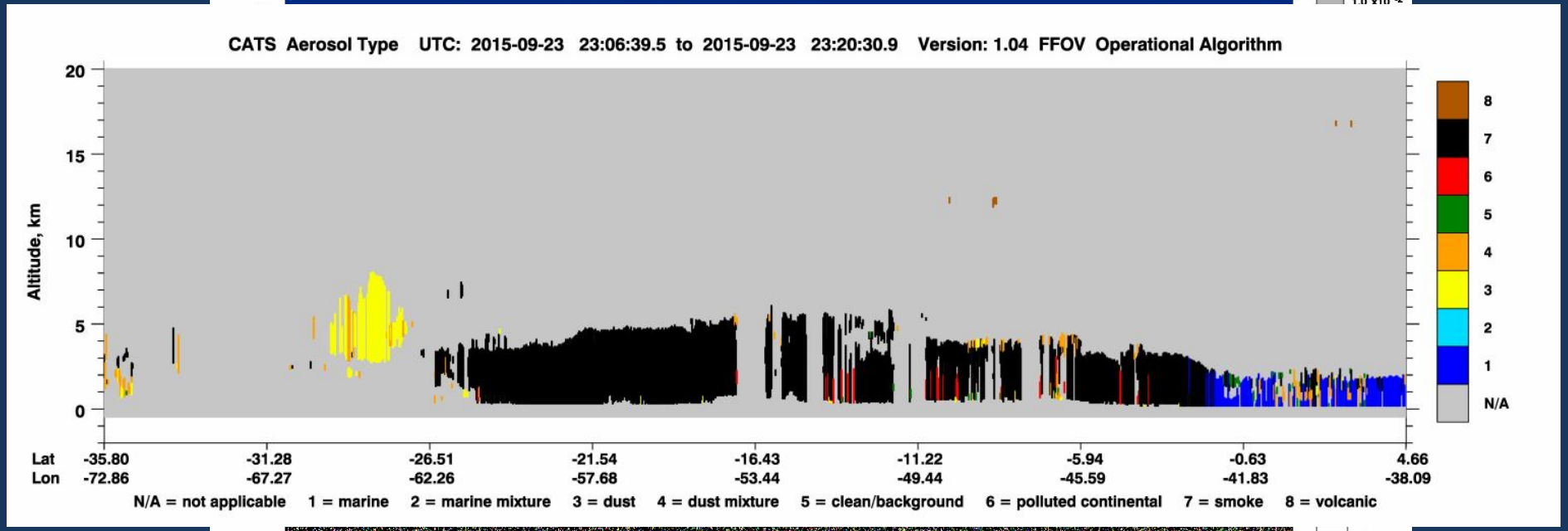


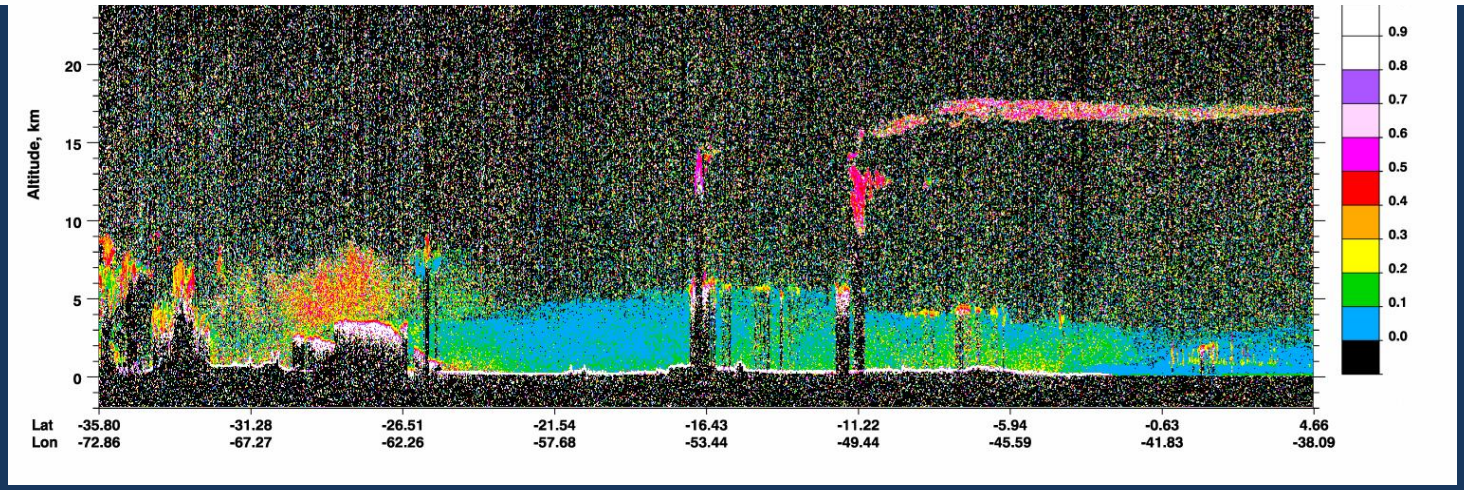


Case Study: Smoke over South America

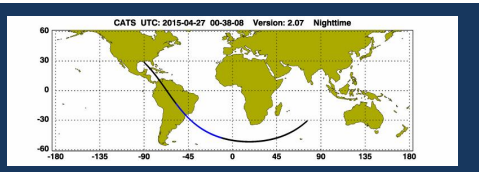


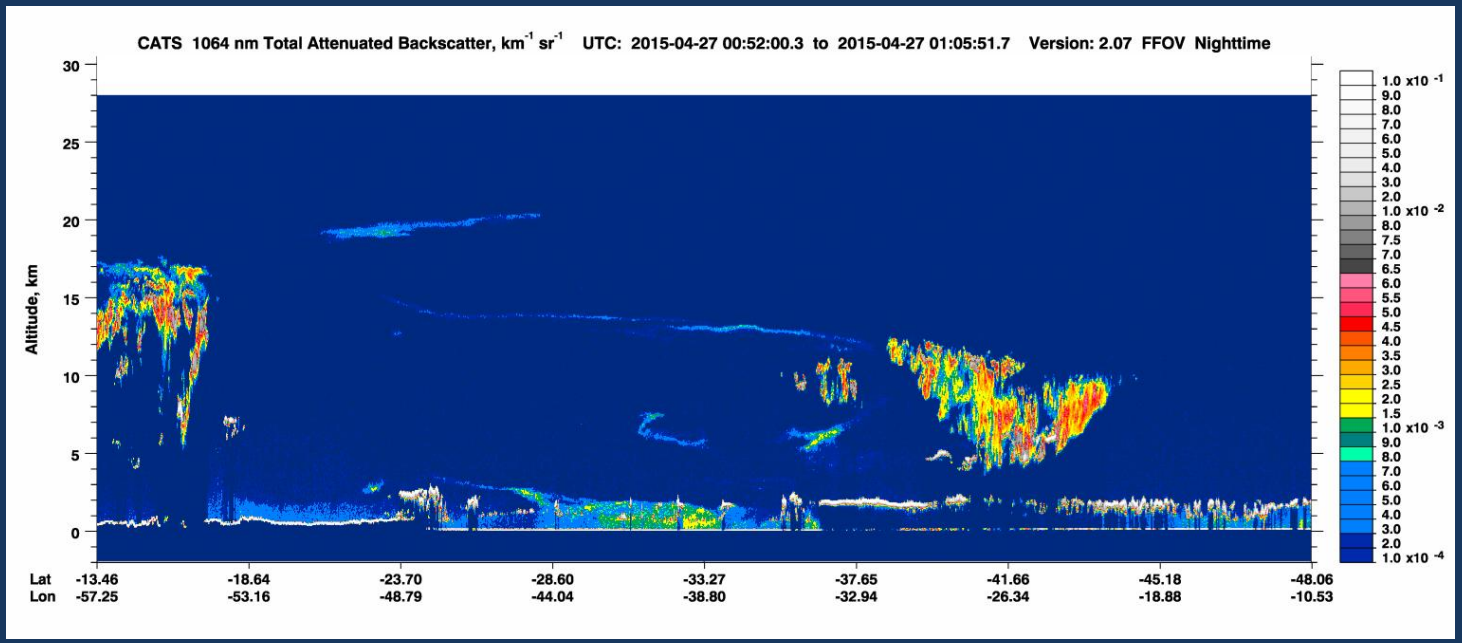


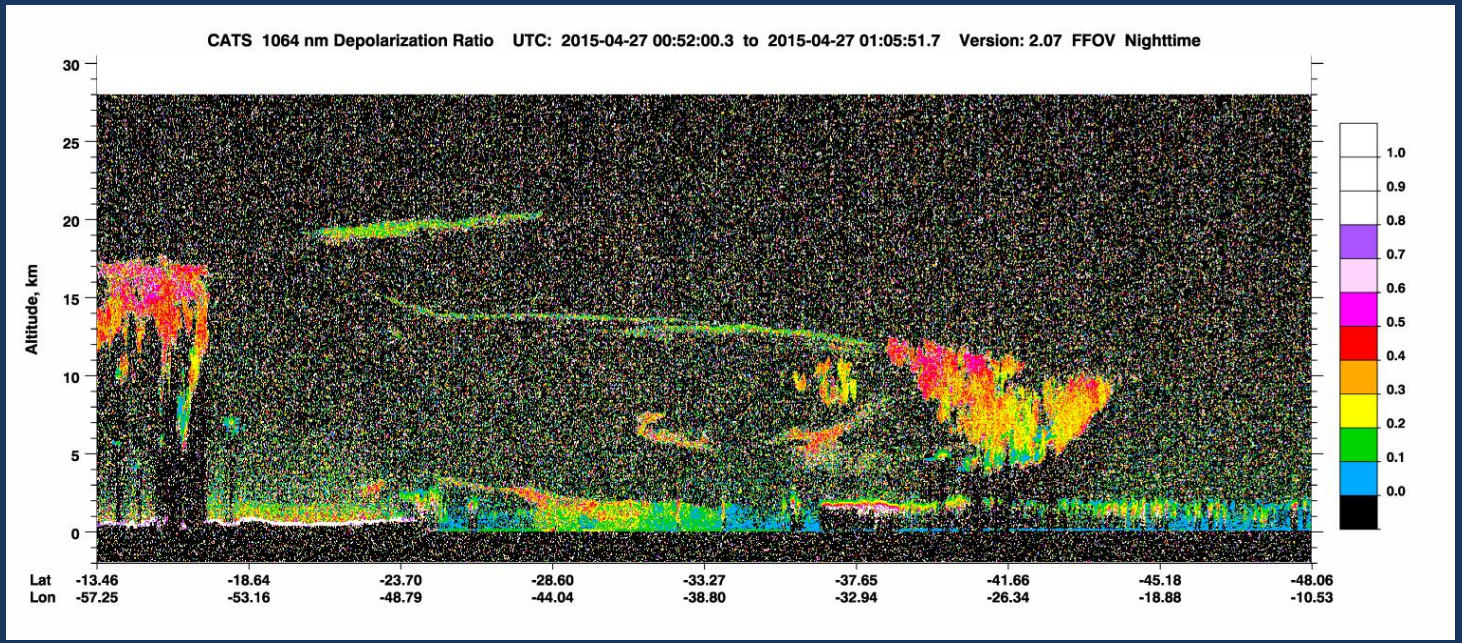




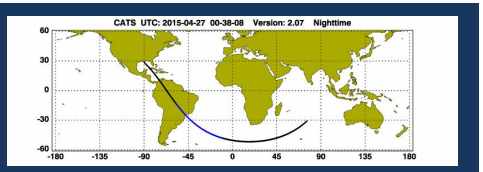
Case Study: Calbuco Eruption

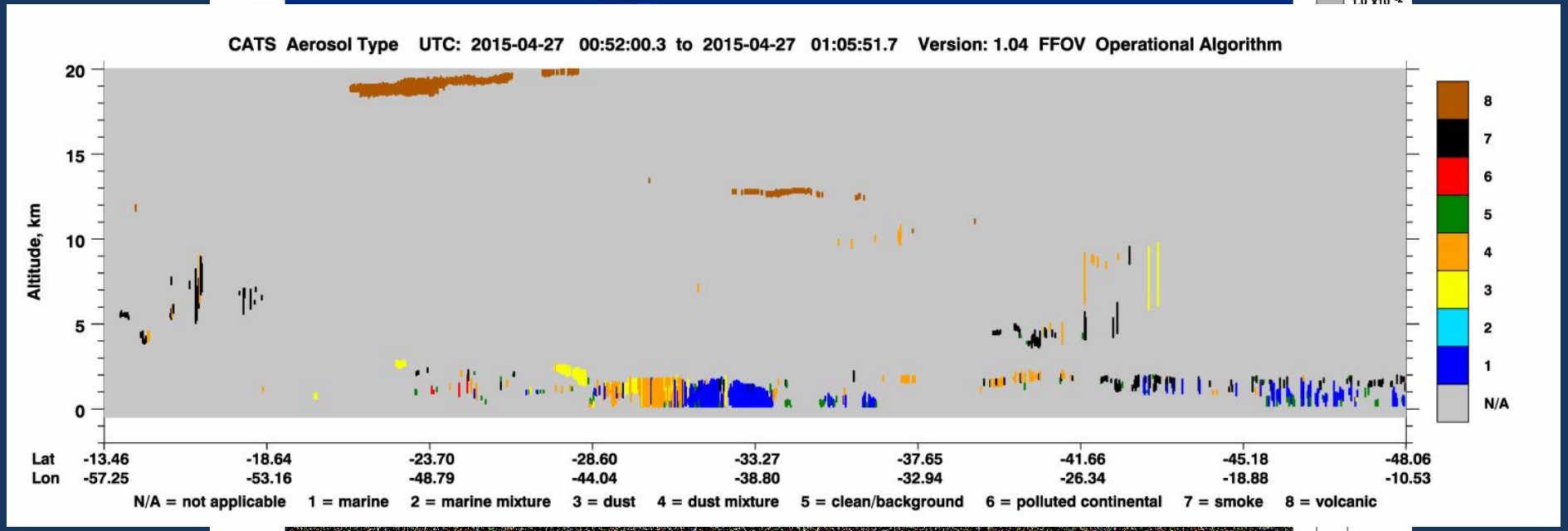


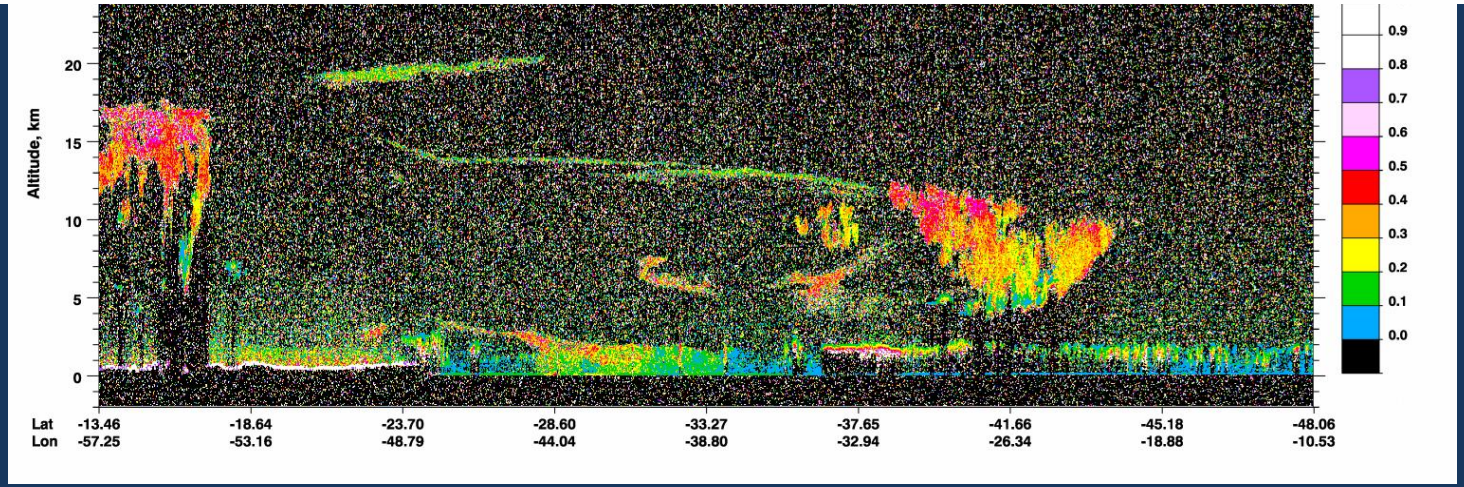




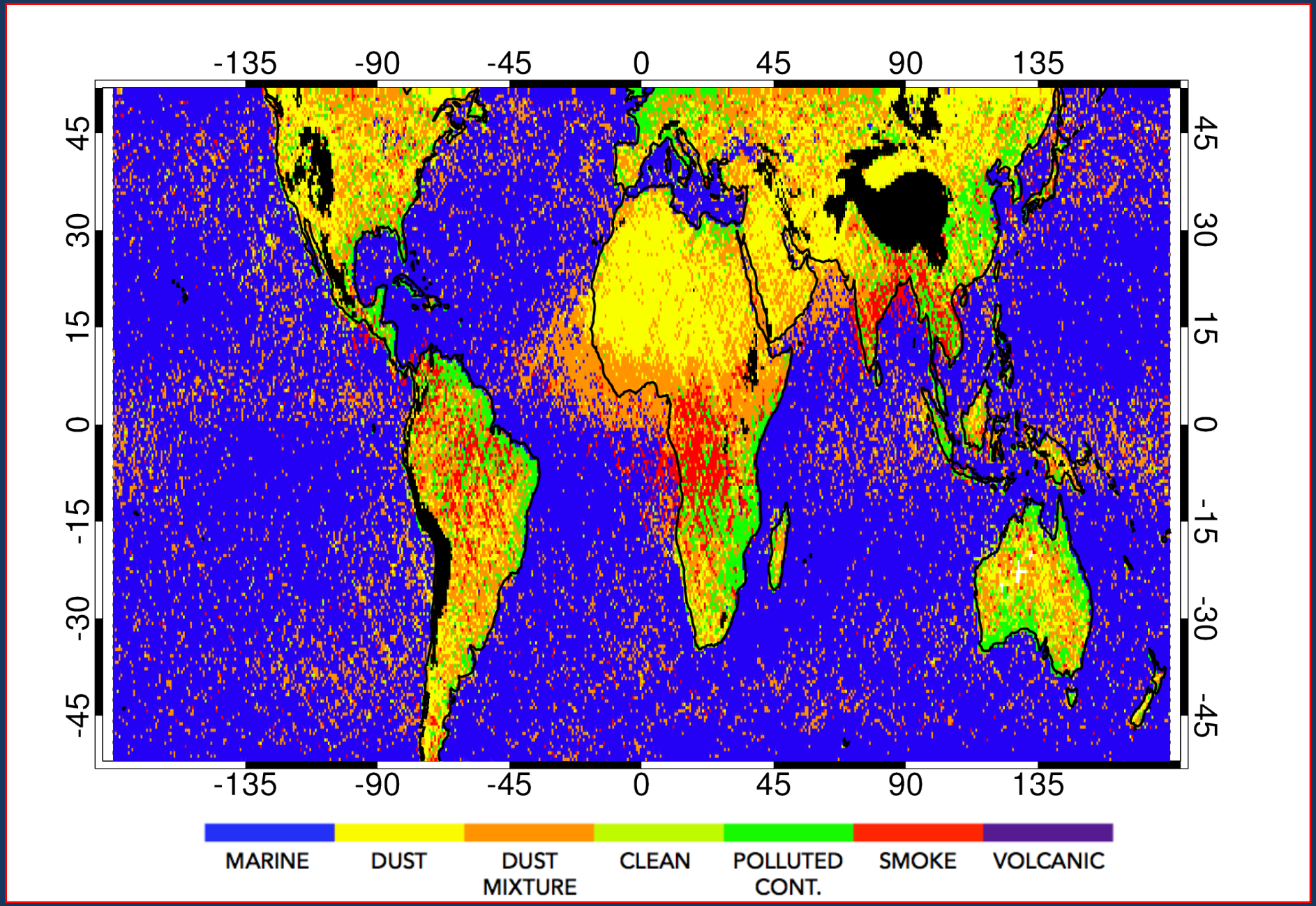
Case Study: Calbuco Eruption



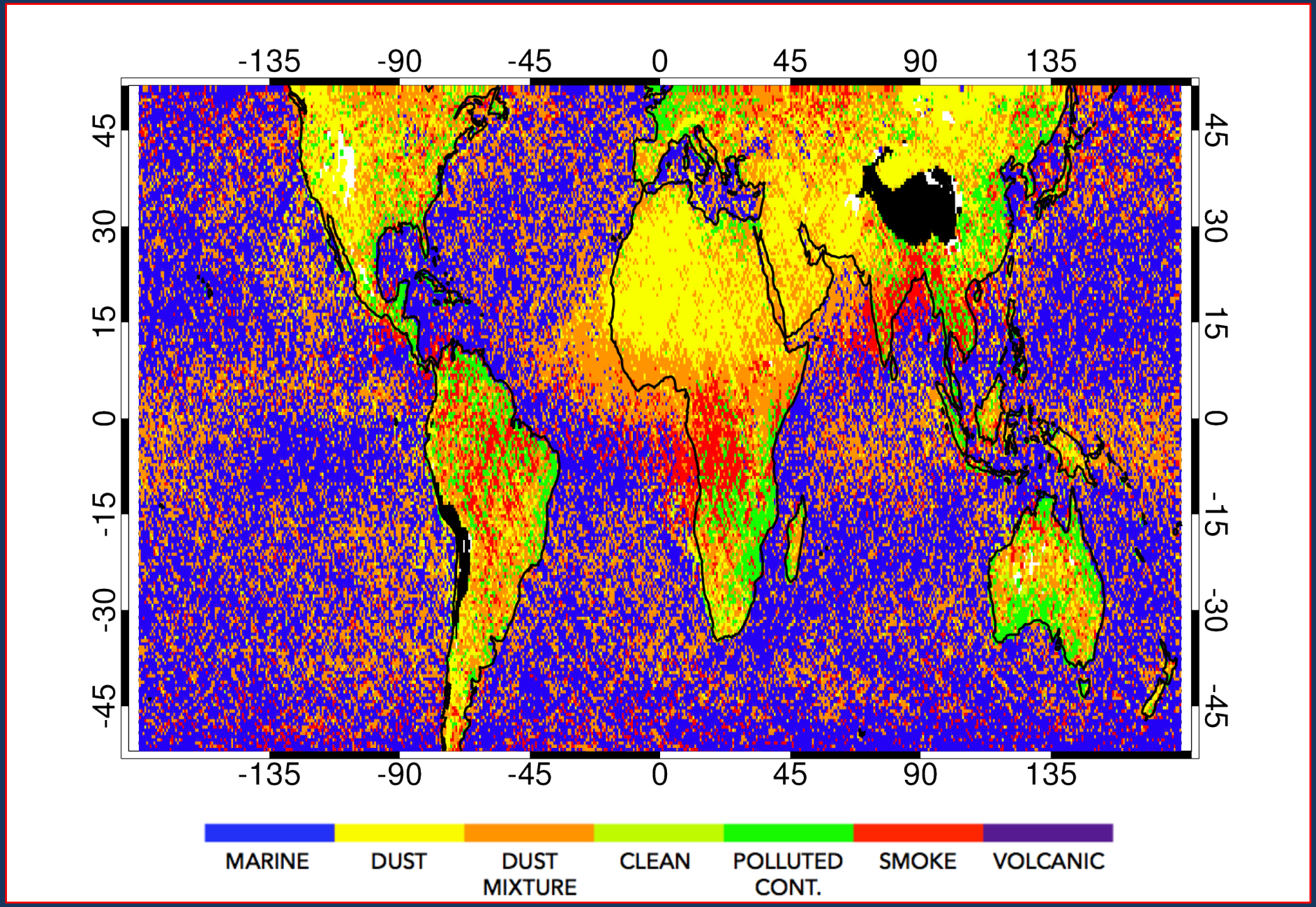




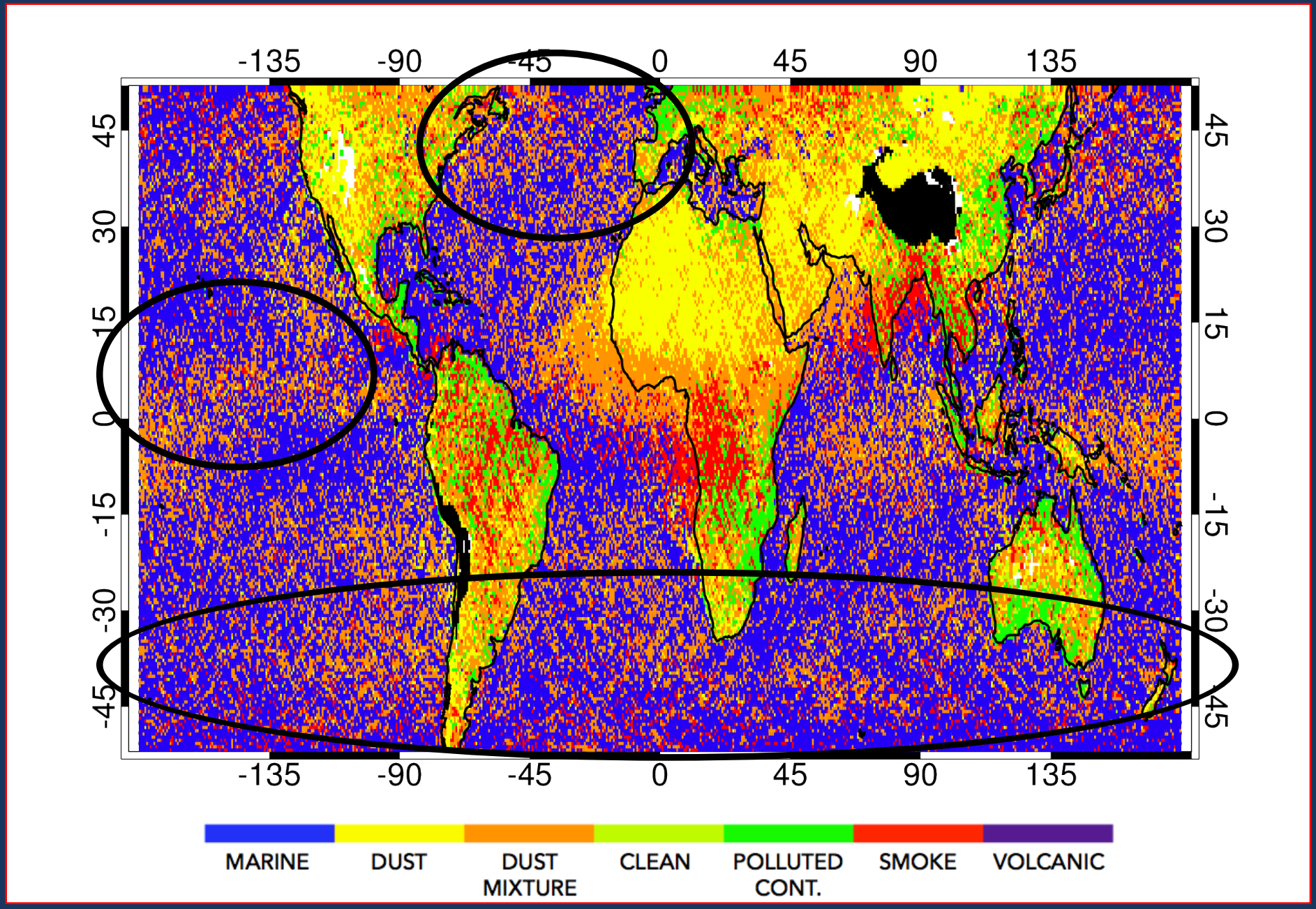
March 2015 – Present Aerosol Typing [0 – 2 km]



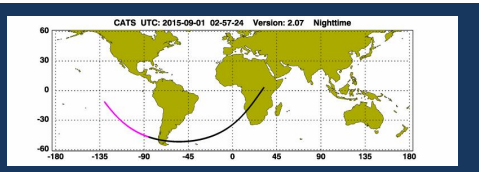
March 2015 – Present Aerosol Typing [1 – 2 km]

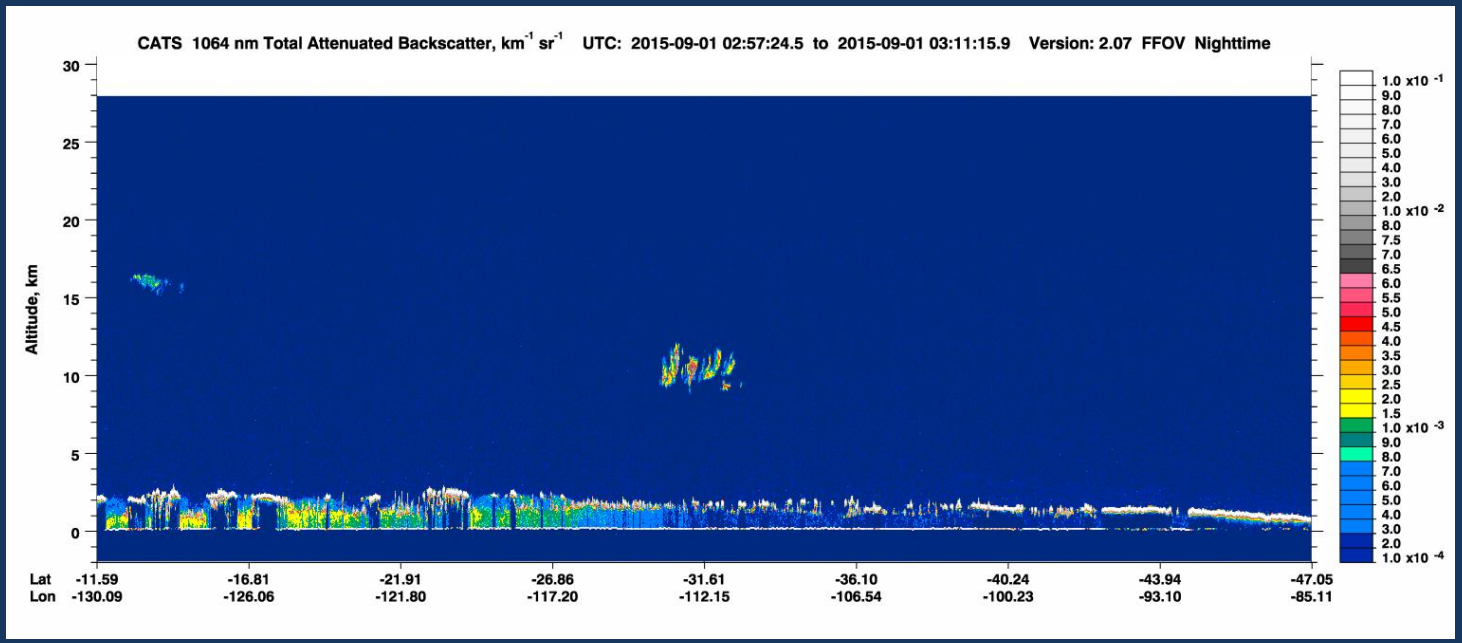


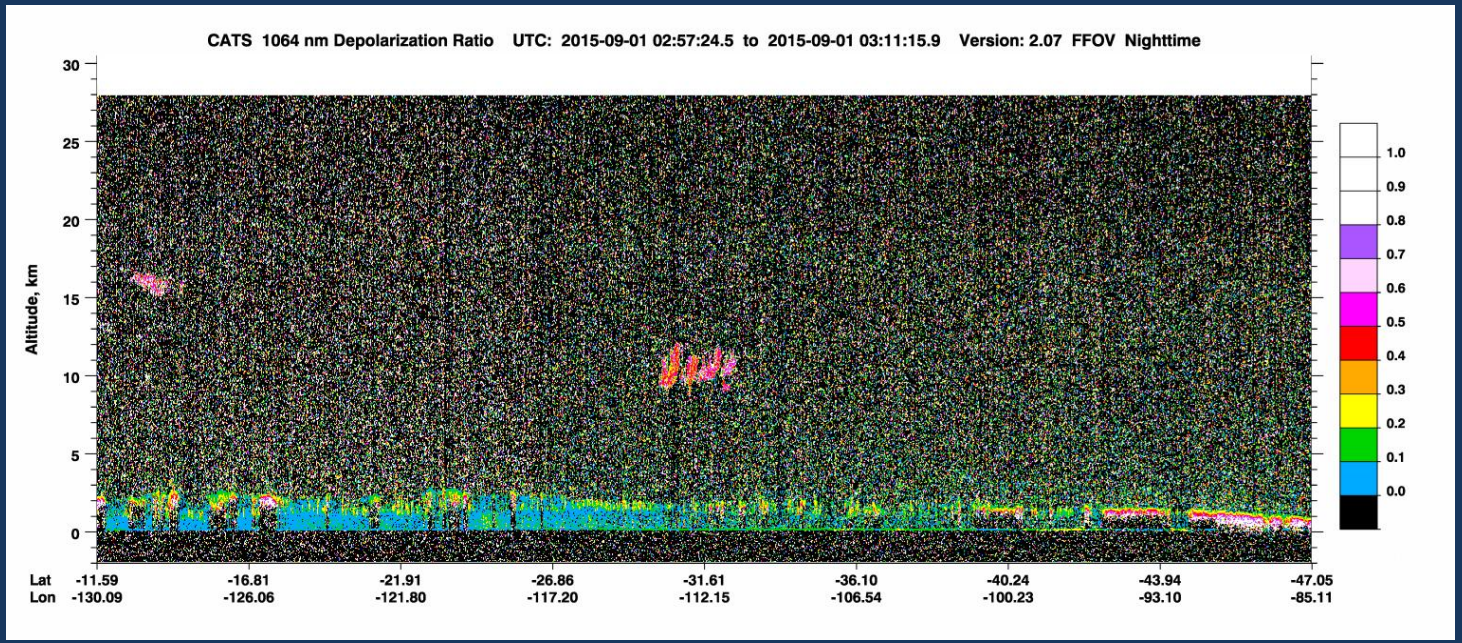
March 2015 – Present Aerosol Typing [1 – 2 km]



Known Issues: High Frequency of Dust Layers







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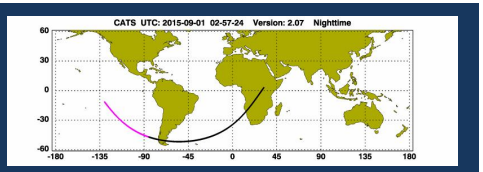
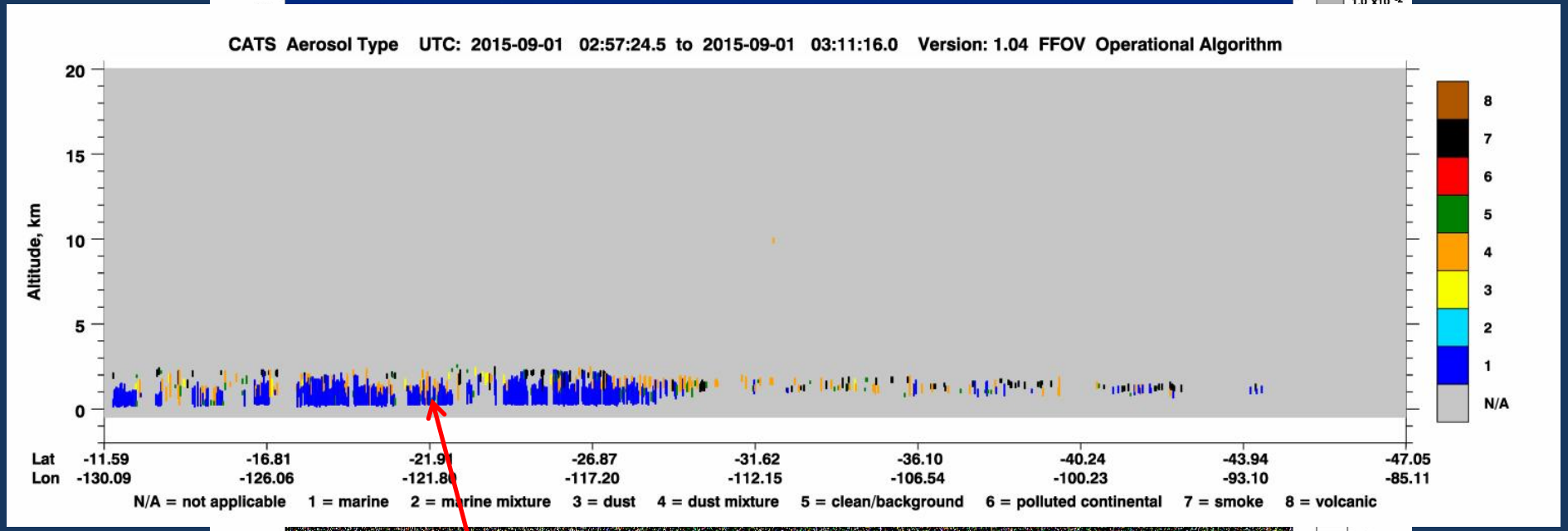
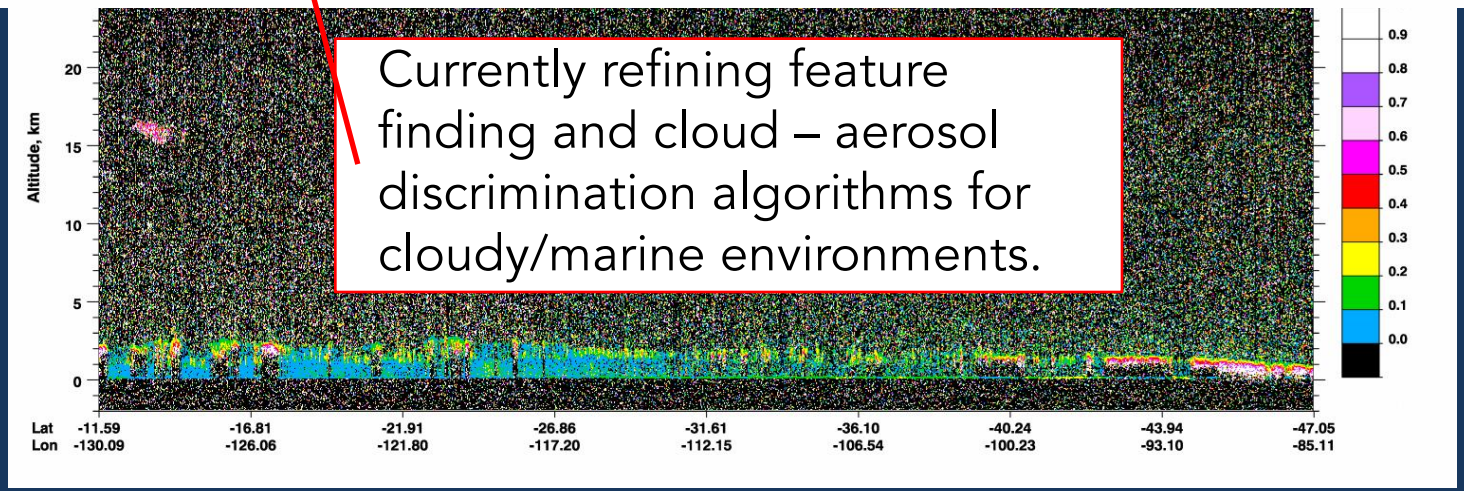
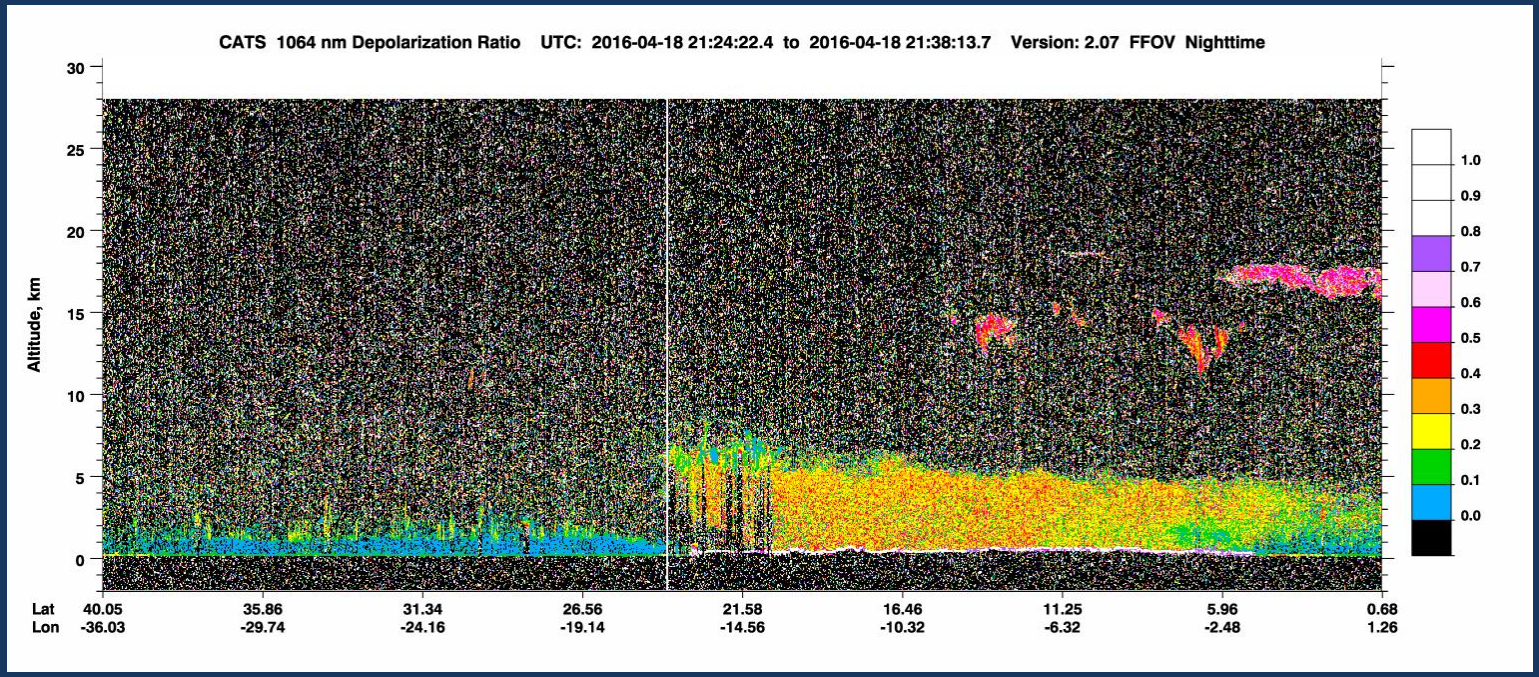


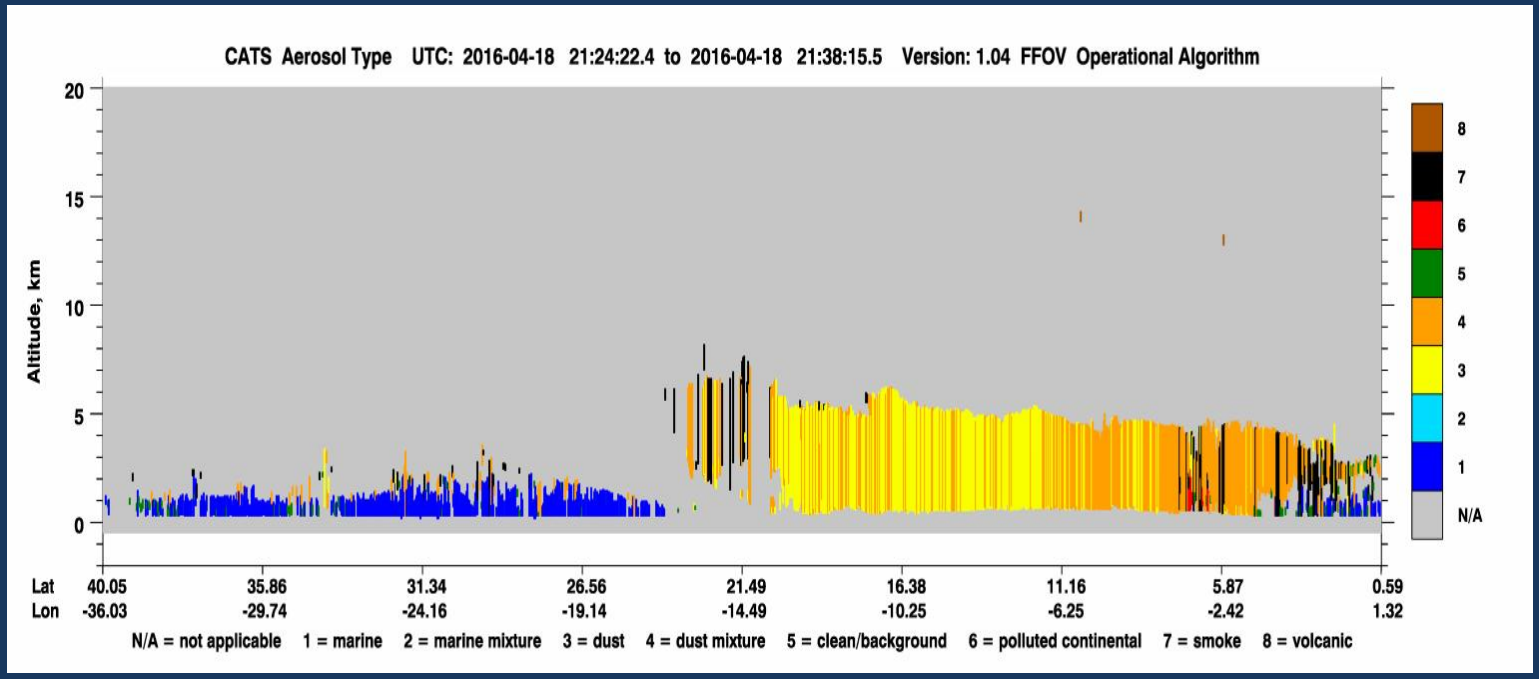




Currently refining feature finding and cloud – aerosol discrimination algorithms for cloudy/marine environments.

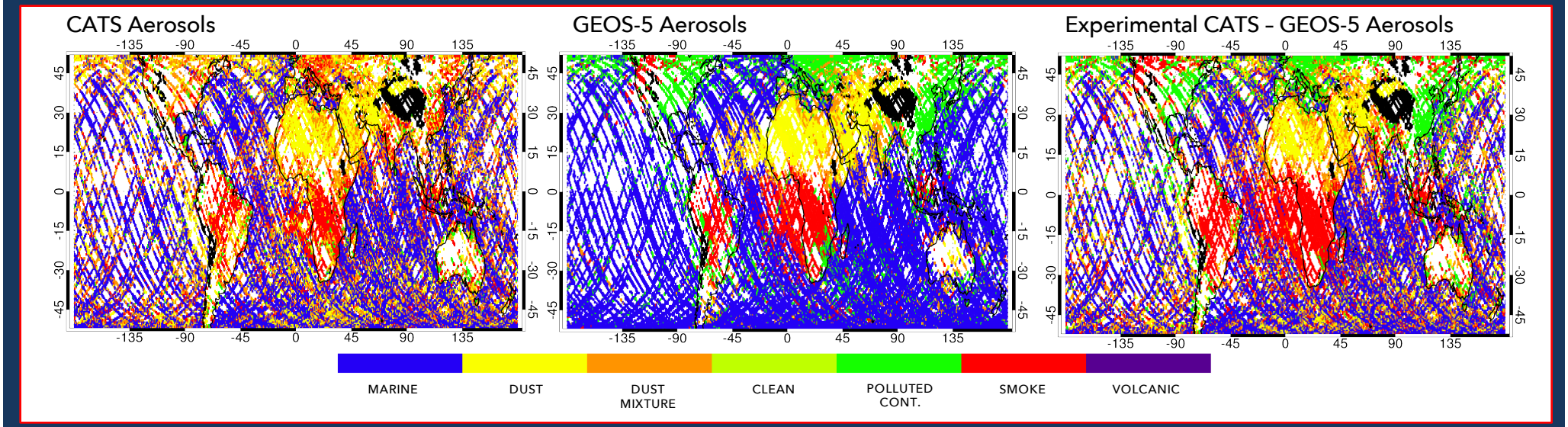
Known Issues: "Striping" within Aerosol Layers





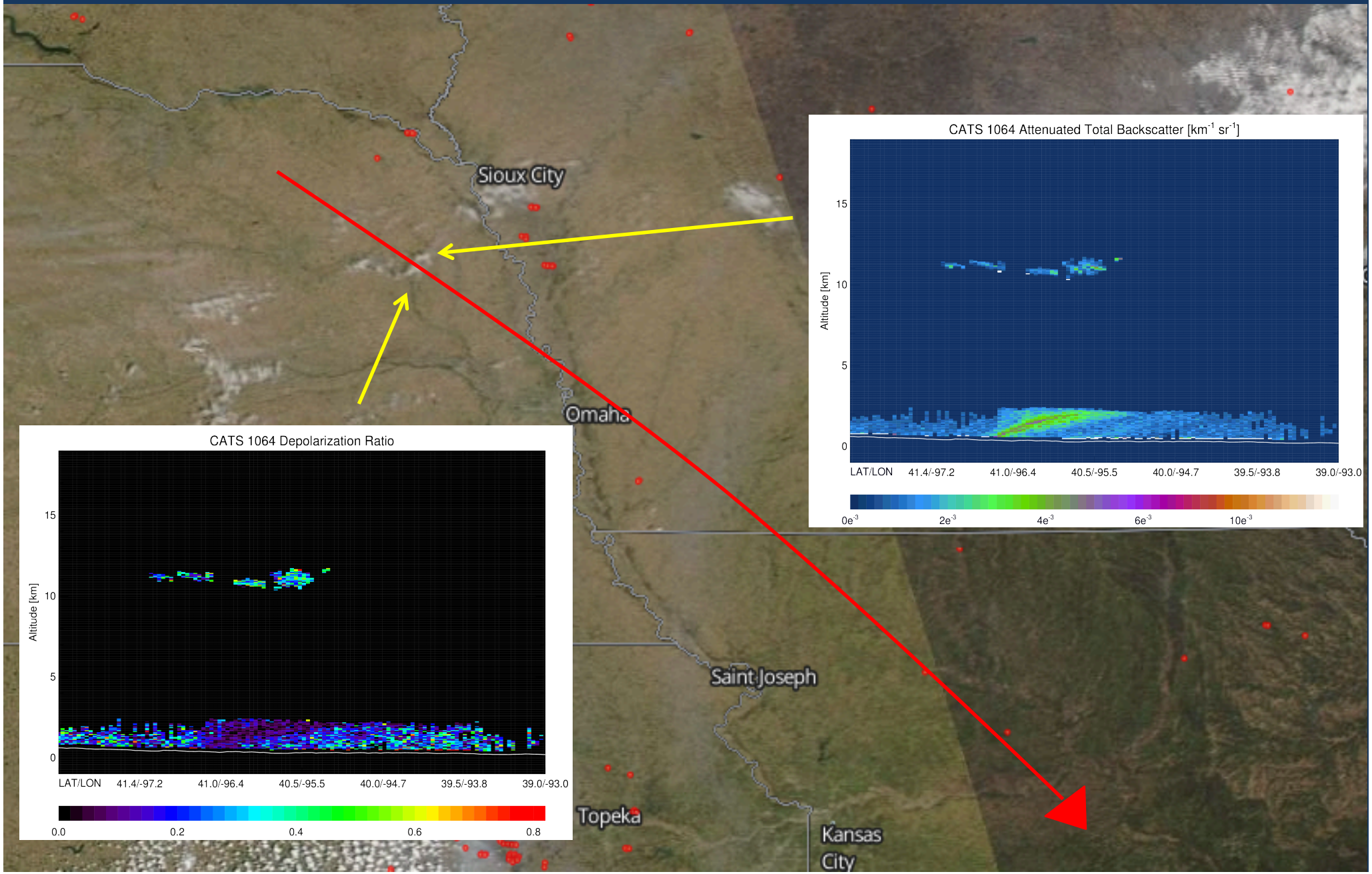
Known Issues: Polluted Continental vs. Smoke Typing

- Differentiation between polluted continental and smoke type depends only on layer thickness and layer base altitude
- Can also lead to "striping" due to set thresholds in algorithm
- Plan to utilize simulated aerosols from the NASA GEOS – 5 AGCM to help classify non – depolarizing aerosol types
    - Aerosol Climatology (ex. MERRA2)
    - 1-D Var Assimilation (in development)

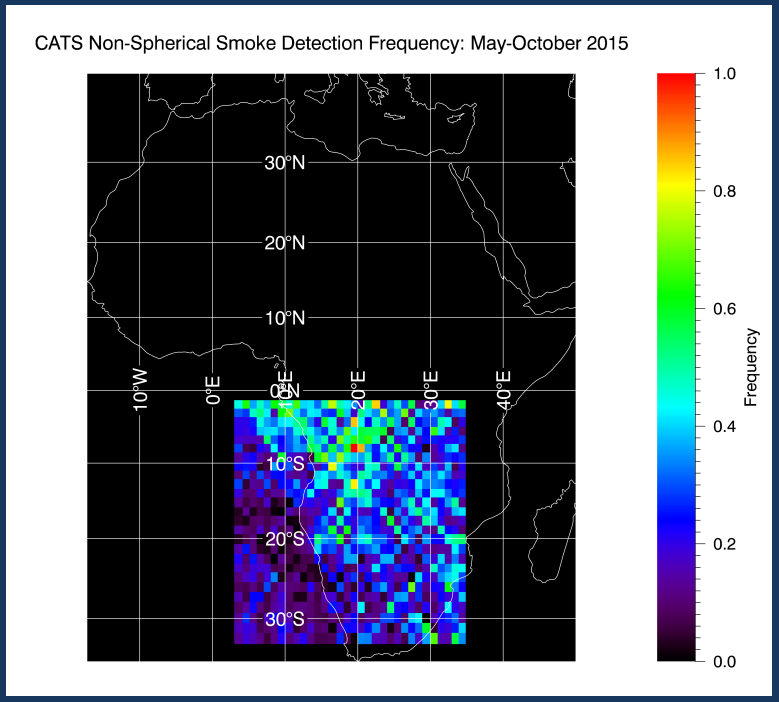


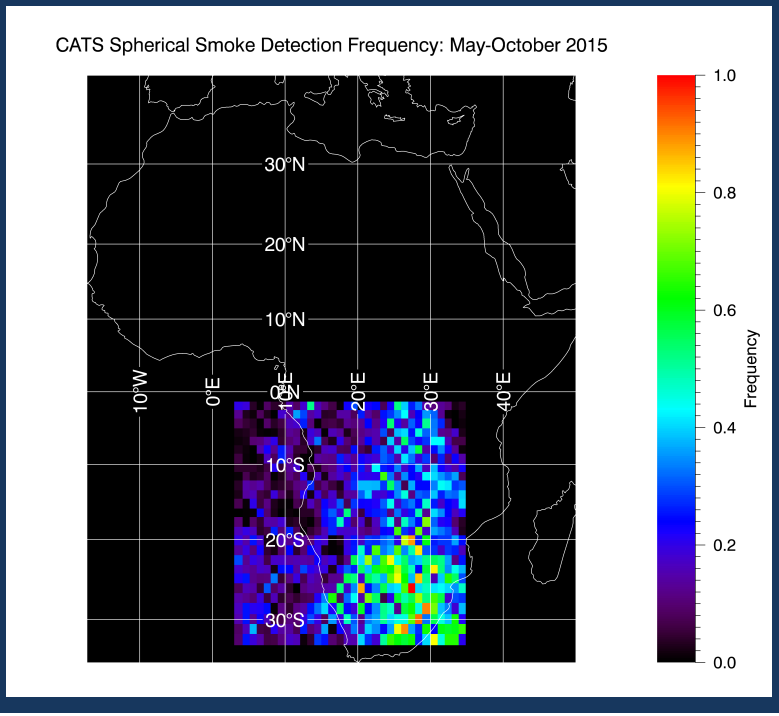
Challenges: Depolarizing Smoke

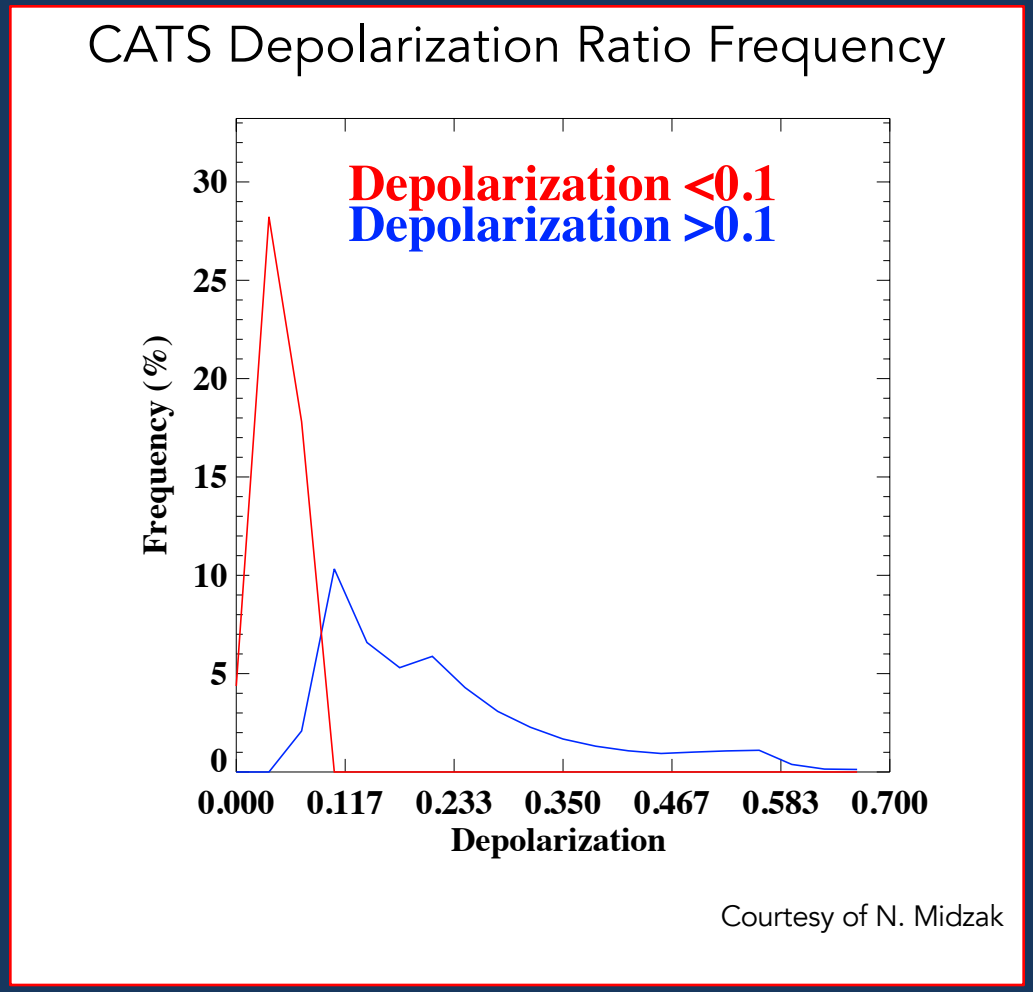
- Active Fires over Nebraska on 4/14/16



Challenges: Depolarizing Smoke







Courtesy of N. Midzak

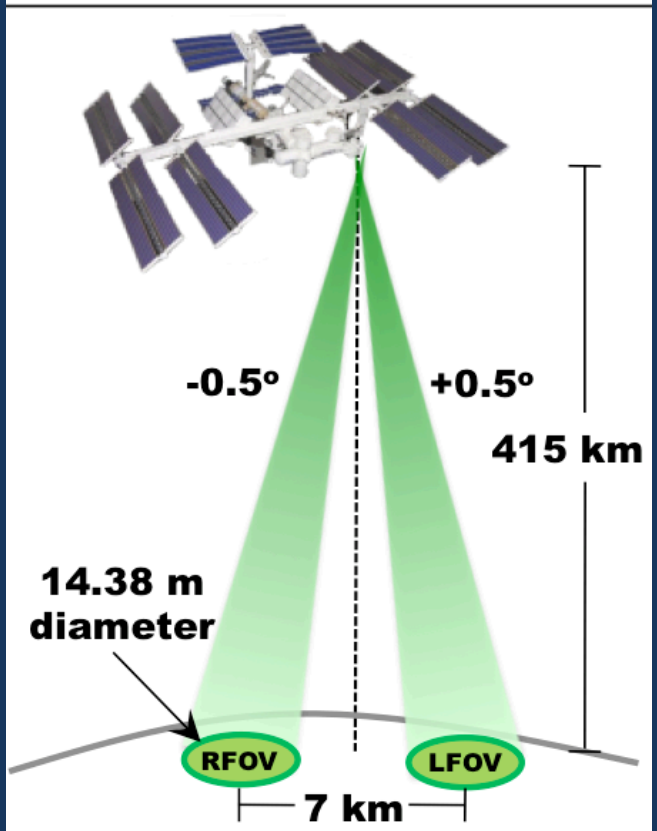
CATS Mode 1 Overview

- Backscatter and Depolarization Ratio at 532 nm and 1064 nm
- 2 different fields of view (left + right)
- Utilize spectral depolarization ratio for aerosol typing

Aerosol Type	532 nm Lidar Ratio	1064 nm Lidar Ratio
Marine	25	45
Polluted Marine	45	40
Dust	45	55
Dust Mixture	35	45
Clean/Background	55	35
Polluted Continental	65	35
Smoke	70	40
Volcanic	45	35

Mode 1: Multi-Beam

Backscatter: 532, 1064 nm
Depolarization: 532, 1064 nm
L2 Products: 532, 1064 nm

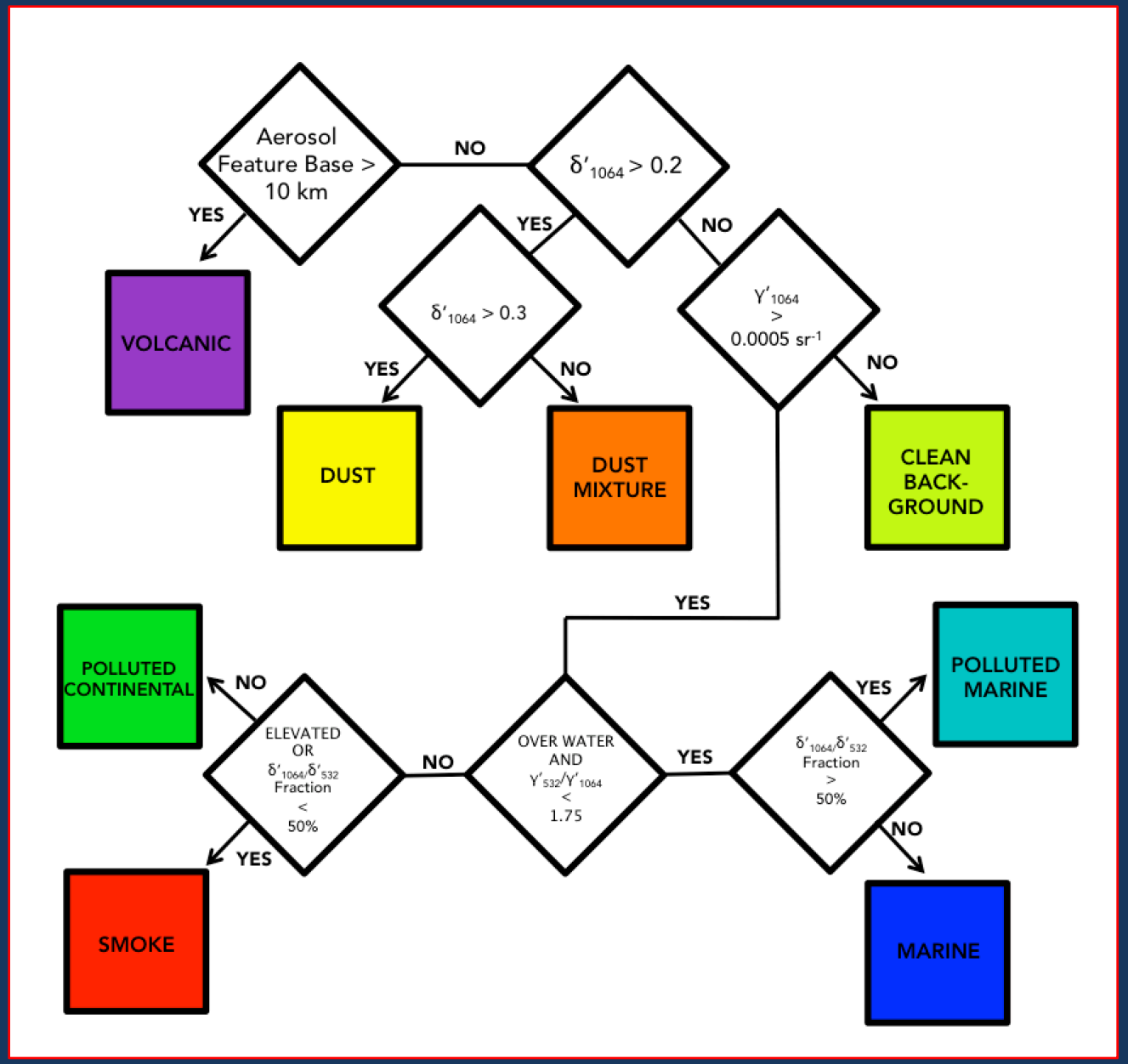


Semi-continuous operation: Feb. 10 – Mar. 21 (2015)

CATS Mode 1 Aerosol Typing Algorithm

Inputs:

- Feature Integrated Depolarization Ratio at 1064 nm (δ'_{1064}) averaged to 5 km horizontally
- Feature Integrated Total Attenuated Backscatter at 1064 nm (γ'_{1064}) averaged to 5 km horizontally
- Surface Type (for maritime)
- Feature Altitude
- Feature Integrated Spectral Depolarization Ratio



Status of CATS Level 2 and Plans for the Future:

Version 1 Aerosol Typing (ongoing):

- Mode 1:
  - L1B data released later this summer
  - L2 data released shortly after
    - Identify algorithm biases (ex. striping, FOV biases)
- Mode 2:
  - Processed & Released
    - Currently working on correcting algorithm issues

Version 2 Aerosol Typing (Fall, 2016):

- Implementation of version 1 modifications
- Integrate GEOS-5 aerosols for typing guidance for non – spherical aerosols

Version 3 Aerosol Typing (2017):

- Implementation of 1-D Var Assimilation into GEOS-5
  - "Dynamic" lidar ratio that will evolve in conjunction with simulated aerosol mixtures

Field Campaign Support:

April – May, 2016

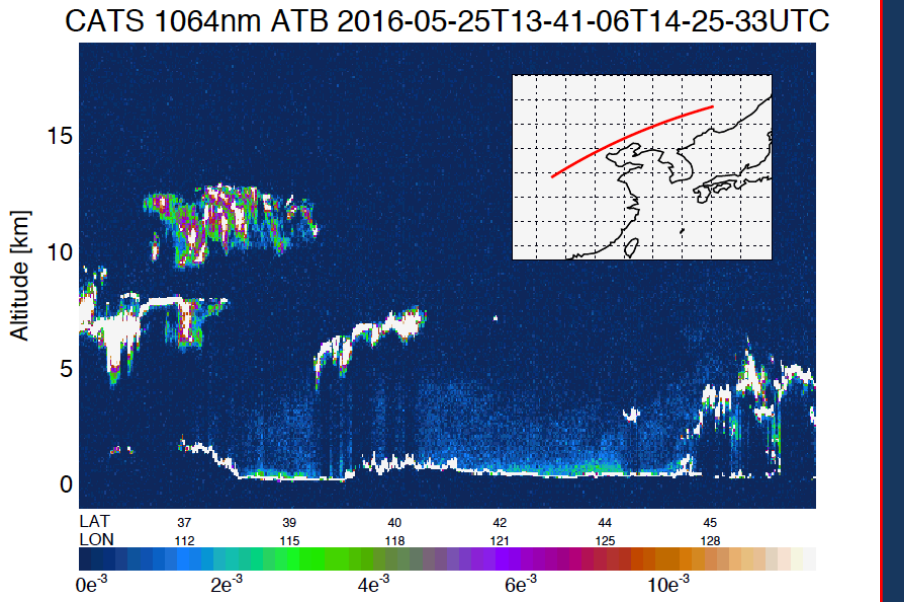
KORUS-AQ

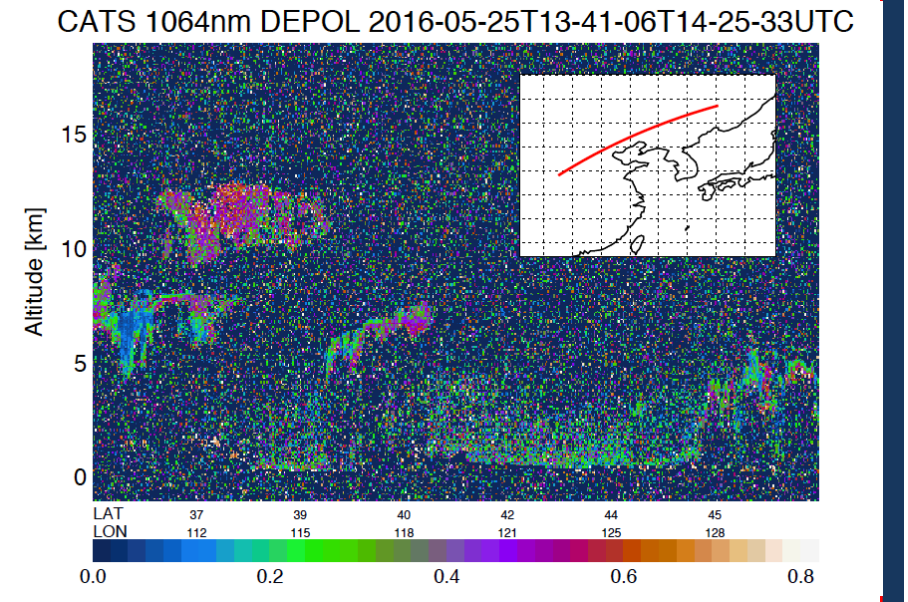
June 2016 - Present

DACCIWA

Starting Fall 2016

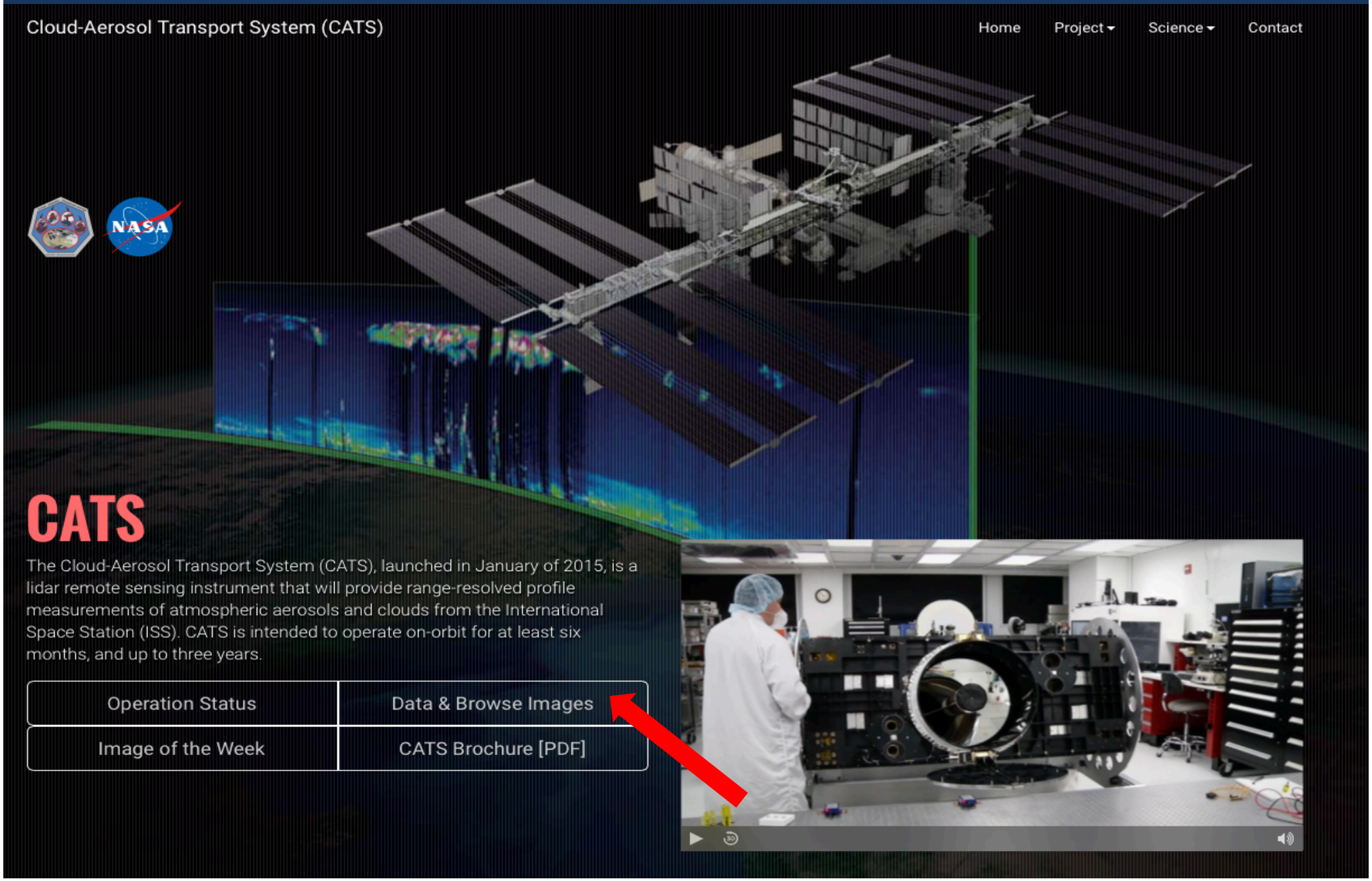
Contacts:
John Yorks – john.e.yorks@nasa.gov
Ed Nowottnick – edward.p.nowottnick@nasa.gov





Getting CATS Data:

https://cats.gsfc.nasa.gov



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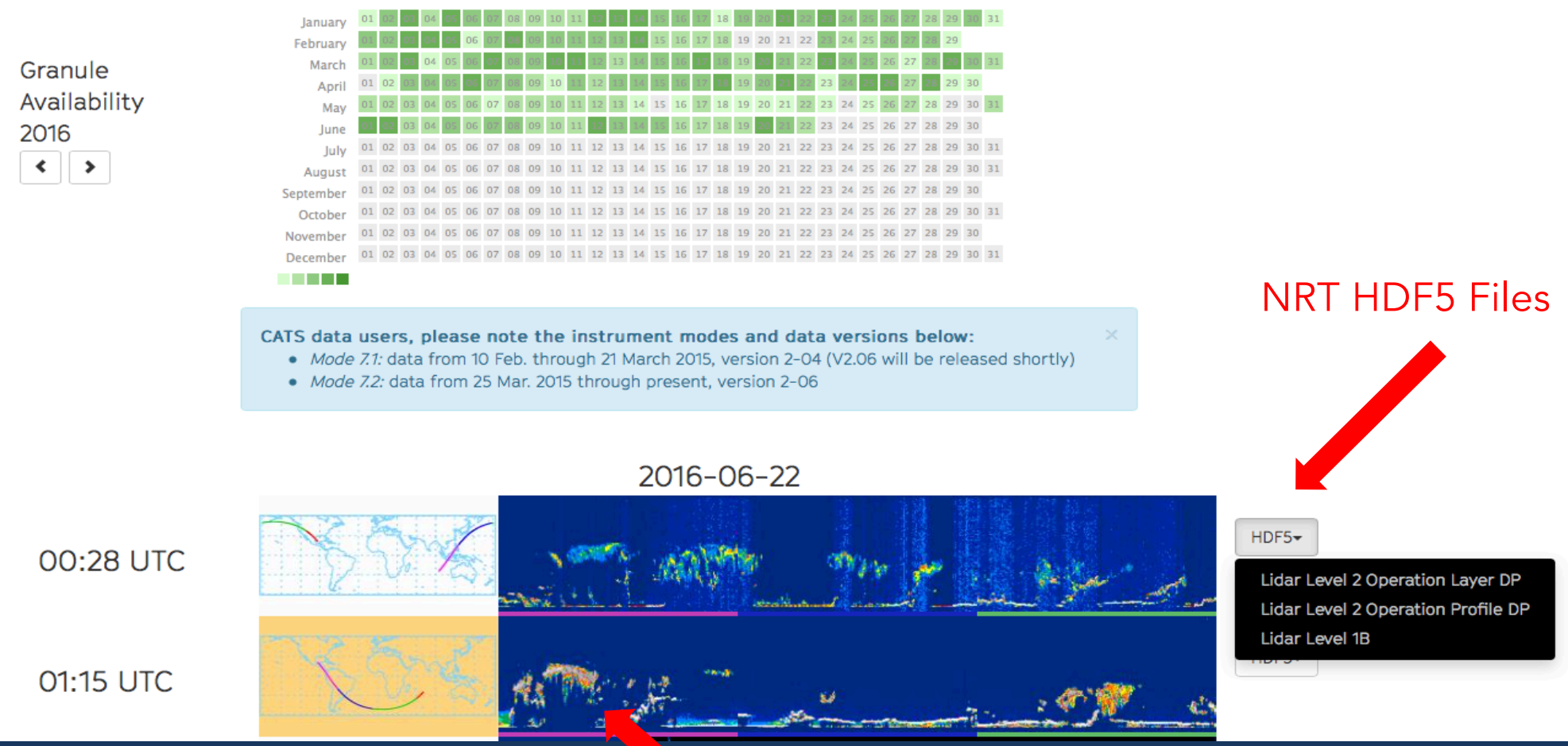

Getting CATS Data:

https://eosweb.larc.nasa.gov/project/cats/